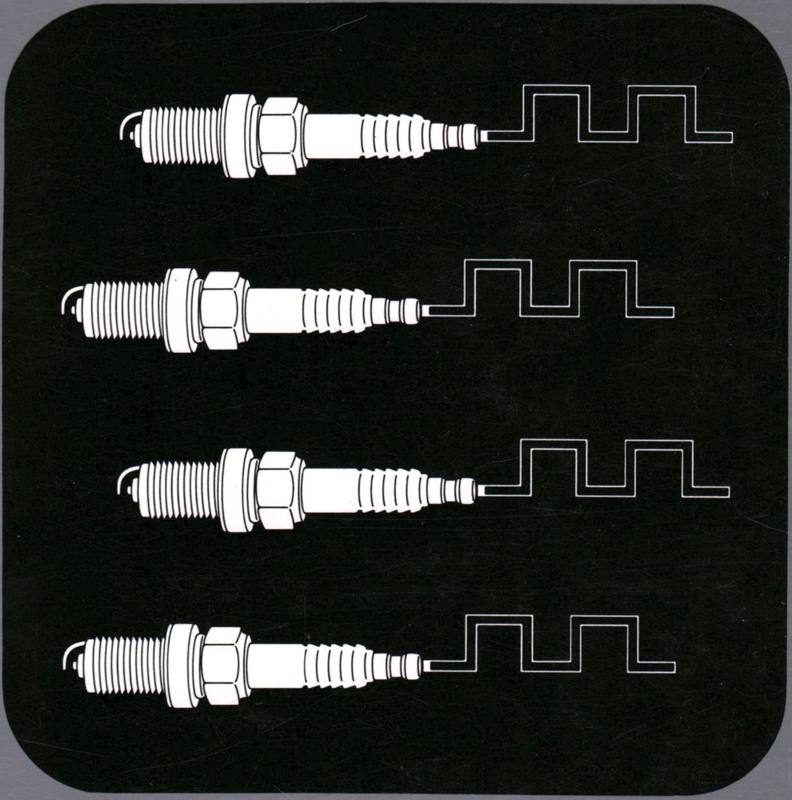
distributorless ignition systems



Supplement to Select STST Courses

STST
Service Technician Specialty Training

Ford Parts and Service Division
Technical Training

IMPORTANT SAFETY NOTICE

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles, as well as the personal safety of the individual doing the work. This manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools, and parts for servicing vehicles, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from instructions provided in this manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools or parts.

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the vehicle. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on a vehicle.

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the vehicle.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on the vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for a specific service operation. If you have a manual transmission, it should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific service operation.
- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts when the engine is running, especially the fan and belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
- Do not smoke while working on the vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind your head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

The recommendations and suggestions contained in this manual are made to assist the dealer in improving his dealership parts and/or service department operations. These recommendations and suggestions do not supersede or override the provisions of the Warranty and Policy Manual or the Shop Manual and in any cases where there may be a conflict, the provisions of the Warranty and Policy Manual or the Shop Manual shall govern.

The descriptions, testing procedures, and specifications in this handbook were in effect at the time the handbook was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications, design, or testing procedures without notice and without incurring obligation. Any reference to brand names in this manual is intended merely as an example of the types of tools, lubricants, materials, etc., recommended for use. Equivalents, if available, may be used. The right is reserved to make changes at any time without notice.

WARNING: Many brake linings contain asbestos fibers. When working on the brake components, avoid breathing the dust. Breathing the asbestos dust can cause asbestosis and cancer.

Breathing asbestos dust is harmful to your health.

Dust and dirt present on car wheel brake and clutch assemblies may contain asbestos fibers that are hazardous to your health when made airborne by cleaning with compressed air or by dry brushing.

Wheel brake assemblies and clutch facings should be cleaned using a vacuum cleaner recommended for use with asbestos fibers. Dust and dirt should be disposed of in a manner that prevents dust exposure, such as sealed bags. The bag must be labeled per OSHA instructions and the trash hauler notified as to the contents of the bag.

If a vacuum bag suitable for asbestos is not available, cleaning should be done wet. If dust generation is still possible, technicians should wear government approved toxic dust purifying respirators.

OSHA requires areas where asbestos dust generation is possible to be isolated and posted with warning signs. Only technicians concerned with performing brake or clutch service should be present in the area.

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Produced and Coordinated by
David J. Lehmer
Technical Training
Ford Parts and Service Division

STST

Service Technician Specialty Training

Ford Parts and Service Division
Technical Training

WHAT YOU SHOULD KNOW ABOUT TECHNICIAN SPECIALTY TRAINING

The Key — SPECIALTY...

STST changes the approach to training by specifically identifying and tailoring training according to your chosen specialty.

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When you have completed this group of courses, you will be recognized as the specialist technician that you are!

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STST

Service Technician Specialty Training

Ford Parts and Service Division
Technical Training

Course Requirements By Service Specialty

STST Curriculum	Service Specialties								
	Engine Performance 31	Engine Repair 32	Suspension & Steering 33	Electrical Systems 34	Climate Control 35	Manual Transmission and Drive Train 36	Automatic Transmission and Drive Train 37	Brakes 38	Pre-Delivery 39
Electrical Systems (5 days)†	X[1]	O	O	X	X[1]	O	X	X[1]	O
Gas Engine Operations (4 days)†	X	X							
Electronic Engine Control (5 days)†	X								
Advanced Engine Performance (2 days)†	X								
Diesel Engine Operations (4 days)†	O[2]	X[2]							
Engine Repair (4 days)	O	X							
Suspension (2 days)†			X						
Steering (2 days)†			X						
Brake Systems (2 days)†								X	
Climate Control Systems (3 days)†					X				
Manual Transmission (2 days)						X			
Rear Axle & Driveshaft (1 day)						X			
NVH (1 day)†			X			X			
Automatic Transmission Rear-wheel Drive (5 days)†							X		
Automatic Transmission Front-wheel Drive (5 days)†							X		
Automatic Transmission Advanced Diagnostics (2 days)							X		
Pre-Delivery (1 day)†									X

O = Optional, but recommended
†Courses available for training in 1989
[1] Prerequisite course
[2] Ford Dealers

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OVERVIEW OF IGNITION SYSTEMS

INTRODUCTION TO THE DIS PROGRAM

The ignition system, of course, is critical for the operation of the internal combustion engine. Improving the ignition system is one way to improve combustion and engine performance. The distributorless ignition system (DIS) is the most recent development in the evolution of the ignition system. The intent of this program is to introduce you to DIS.

Understanding ignition systems requires an understanding of electricity and magnetism. As a technician, you may have questions about the purpose of the sensors, modules or other ignition system components. You may wonder how 12 volts from the battery results in 40,000 volts at the spark plugs. This program will answer many of your questions.

By understanding the basic operating principles of ignition systems, you will be better prepared for diagnosing, testing and servicing DIS.

This DIS program covers the basics of ignition systems plus the details of the distributorless ignition system. After studying this manual, you will have a broad background in ignition systems and knowledge of the details of DIS.

For example:

- Section 1 provides an overview of ignition systems, a brief history of ignition systems, and a comparison to DIS.
- Section 2 explains the fundamentals behind ignition system operation and how electricity and magnetism provide the energy needed for combustion. This section is useful as an introduction or a review of the principles and operation of ignition systems.
- Section 3 describes the components of DIS and their functions.
- Section 4 details the operation of DIS on 3.8L Supercharged (SC), 3.0L Super High Output (SHO) and 2.3L Dual Plug (DP) engines.
- Section 5 provides information about DIS diagnosis. This includes information about the equipment required and how to use the equipment to diagnose and test DIS.
- Section 6 centers around the servicing needs of DIS and explains important servicing points.

PROGRAM PREREQUISITES

Technicians participating in this program should already have a basic knowledge of the following:

- standard safety precautions for automotive service.
- component identification for Ford Motor Company TFI-IV ignition systems.
- basic operation of the internal combustion, four-cycle gasoline engine.
- basic understanding of electricity and magnetism.
- EEC-related driveability diagnosis.
- Non-EEC related driveability diagnosis.

SUGGESTED PUBLICATIONS

If you are interested in expanding your background in automotive electronics or engine ignition systems, or you need additional information, the following Ford publications are recommended:

- 1973-1985 BASIC ENGINE IGNITION SYSTEMS, Order Number 2301-207. This text describes the evolution and function of the ignition system from its most basic form to today's fully electronic/computerized systems. It includes a 106 word glossary of related technical terms.
- BASIC AUTOMOTIVE ELECTRONICS
  - PART ONE, Order Number 3000-109. This course covers the use of electronics in modern vehicle systems. Electron theory is reviewed and the application of microprocessor circuitry is explained.
  - PART TWO, Order Number 3000-110. Part Two concentrates on the "conventional electrical system" highlighting 23 electrical systems including diagnosis and testing.
  - PART THREE, Order Number 3000-111. Part Three concentrates on electronic circuits and how they operate within the overall system. The covered systems are: electronic instrument clusters, electronic message centers, and electronic engine control systems.
  - PART FOUR, Order Number 3000-113. Part Four contains basic electrical/electronic troubleshooting. It explains the operation of test equipment in isolating

problems in electrical circuits and enables the student to develop basic troubleshooting techniques.

- SOLID-STATE IGNITION SYSTEMS, Order Number 2301-006. This text discusses how solid-state ignition works; such as the differences between solid-state and breaker point systems, diagnosis, and oscilloscope testing.
- ELECTRONIC ENGINE CONTROL STRATEGIES, Order Number 0901-056. This publication introduces the basics of EEC-IV strategies with examples from a variety of engine packages.

  Descriptions include the functions of major engine control systems; engine requirements at various stages of operation; and basic strategies for controlling major engine control systems, such as fuel control, spark, idle speed control, and EGR in different engine operating states.
- AUTOMOTIVE MICROCOMPUTER SYSTEMS, Order Number 0901-225. Included in this text is an explanation of the functions of microcomputers and an introduction to basic principles behind microcomputer construction and operation. The manual begins with a concise history of the microcomputer and ends with an outline of its use in improving vehicle efficiency.
- NON-EEC RELATED DRIVEABILITY DIAGNOSIS, Order Number 0901-052. This course provides instructional material to enhance knowledge and improve the skills necessary to diagnose non-EEC related concerns.
- EEC-RELATED DRIVEABILITY DIAGNOSIS, Order Number 0901-054. This course provides instructional material necessary to identify and diagnose electronic engine control (EEC) related driveability concerns utilizing the car/truck engine emission diagnosis shop manual (Volume-H).

To order any of these publications, refer to the Service Training Materials Catalog. The catalog is available through Ford Service Publications, Post Office Box 07150, Detroit, Michigan 48207.

PROGRAM OBJECTIVES

After completing this training course, you will be able to:

- describe the components that are used in DIS.
- identify the DIS components and their location in the engine compartment.
- describe how each component operates.
- describe the function or functions each component performs for the DIS.
- describe how these components work together when the engine is operating.
- identify what equipment is required to diagnose DIS.
- identify what optional equipment is available for diagnosing DIS.
- install and use the DIS diagnostic equipment.
- describe the important points to remember when servicing DIS.

HISTORY OF IGNITION SYSTEMS

Basically, the ignition system furnishes a spark to the correct cylinder at the correct time to ignite the fuel mixture. The cylinders must fire in the proper order and must fire at a precise instant, depending on engine speed and engine load conditions.

All ignition systems operate in a similar manner; current flow in the coil primary circuit is interrupted to produce high voltage in the coil secondary circuit which fires the spark plug.

The difference is how the ignition systems control the current in the primary circuit and how the secondary high voltage is distributed to the spark plugs.

MAGNETO

In the earlier vehicles, ignition was furnished by a magneto; a kind of DC generator that produced an extremely high voltage spark. The magneto was connected to a crude distributor that routed the spark to the correct plug at the right time. Usually, these vehicles had no electrical system as we know it. There was no battery, generator, or body wiring.

With the introduction of the Ford Model T, an impressive 8-wire system served the entire ignition system. In fact, it served the entire engine! A low voltage magneto, mounted on the front of the engine, sent timed pulses to four coils mounted in wooden boxes on the rear wall of the engine compartment. The coils, each fitted with armatures and contact points, alternately opened and closed their own operating circuits, thus producing the high voltage secondary current. Four ignition cables routed the spark to the correct plugs (Figure 1-1).

OVERVIEW OF IGNITION SYSTEMS

With the invention of the single point, single coil system, and the adoption of the on-board battery and self starting, components became simpler and less expensive. Battery current through the points energized the primary coil. When the points opened, high voltage resulted in the secondary coil. The distributor routed the high voltage to the correct spark plug. The distributor was connected to or geared to the camshaft so the distributor could determine the position of each piston for correct timing of the spark.

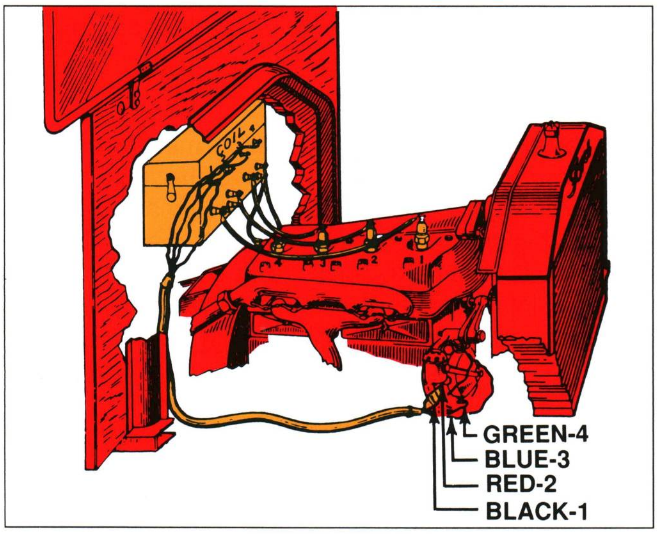


Figure 1-1. Ford Model T Magneto System

BREAKER POINT

Breaker point ignition systems (Figure 1-2) have their drawbacks. The breaker points would wear out both mechanically and electrically. Spring tension, gap, alignment, and wear on the rider were critical to good operation. They were susceptible to damage from water, electrical and mechanical load, improper adjustment and improper service.

Electronic or solid-state ignition systems were an early attempt to remedy at least the electrical shortcomings of the breaker point ignition system. In these transistorized ignition systems, only a small amount of current was carried by the ignition points. The points were used to signal a transistor which turned the current in the coil primary circuit ON and OFF.

A capacitor, installed across the ignition points, soaks up the momentum of electron flow in the primary circuit when the ignition points open. When the points start to open, this electron momentum charges the capacitor rather than jump the point gap. Without the capacitor, arcing quickly causes the contact points to pit and thereby become useless.

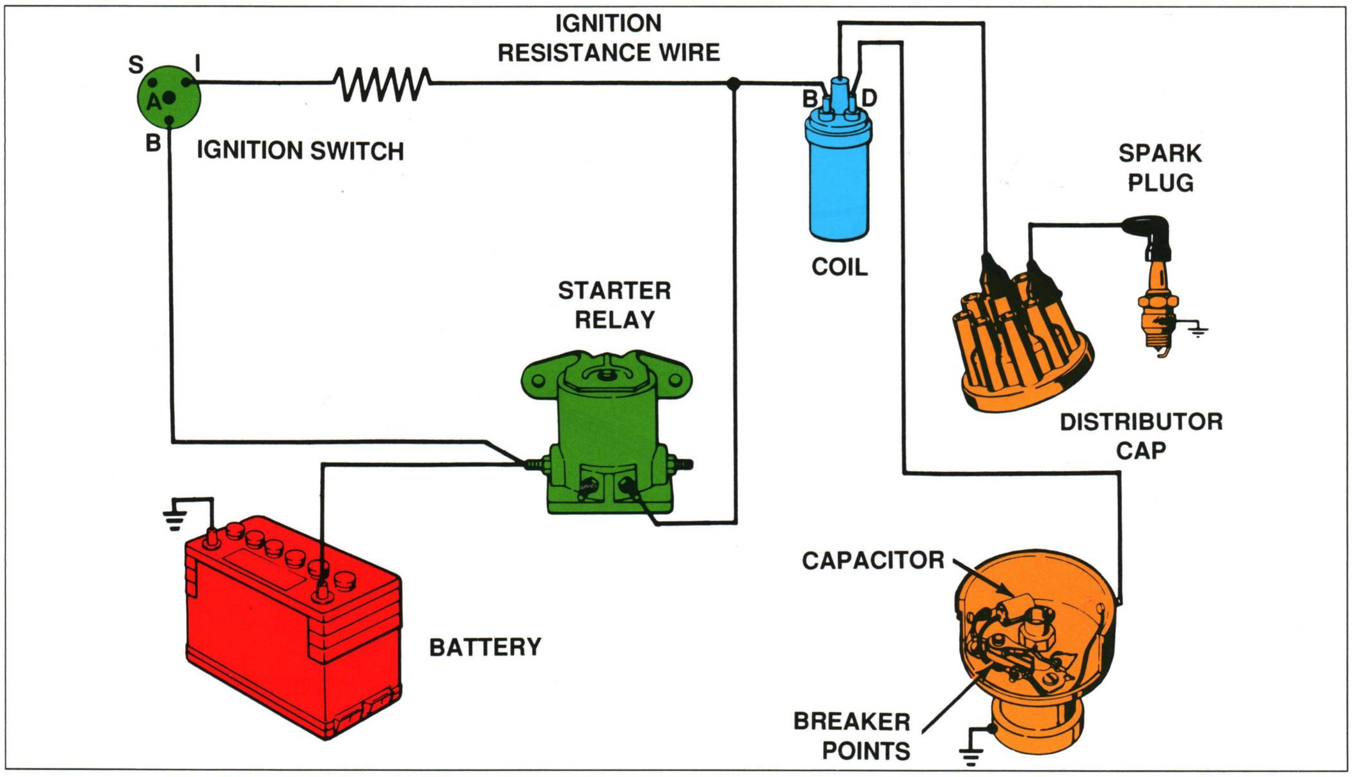


Figure 1-2. Breaker Point Ignition System

OVERVIEW OF IGNITION SYSTEMS

SOLID-STATE IGNITION

In 1975, breakerless Solid-State Ignition (SSI) became standard on all Ford automobiles (Figure 1-3). The distributor cam was replaced with a toothed, soft iron armature. The breaker plate and points were replaced by a pickup coil.

The SSI and the breaker point ignition systems both perform the same functions. In most respects, the distributor in the electronic system and the breaker point system work the same. The rotor, distributor cap, spark plug wires and spark plugs all operate the same. Where the conventional system had breaker points, the electronic system uses a pickup coil and armature assembly, plus an ignition module to accomplish the same thing; opening and closing the coil primary at the exact moment spark is needed. The breaker point ignition system and the SSI system both depend on timing advance and retard mechanisms in the distributor. In the electronic system, the dwell is controlled by the ignition module and automatically adjusts itself.

The electronic components used in the breakerless SSI system are the ignition module and pickup coil and armature assembly.

The pickup coil is a signal generator that determines the position of the distributor armature by its effect on the pickup coil (Figure 1-4).

The signal produced by the signal generator is applied to the ignition module which in turn controls the ground path for primary winding in the ignition coil. The secondary circuit operation is the same as that used on the breaker point system.

ELECTRONIC ENGINE CONTROL

All of the functions that used to be done mechanically can now be done through electronics. Over the years, several electronic engine control (EEC) systems have been released for use on Ford-built vehicles. On some of these systems, such as Duraspark III, a crankshaft position sensor (Figure 1-5) is used in place of the magnetic signal generator, armature and pickup coil in the distributor.

A unique feature of Duraspark III, for example, is the elimination of centrifugal and vacuum advance mechanisms in the distributor. Engine timing is not controlled by the distributor but by the ECA. The only job that the distributor performs is the distribution of secondary voltage from the coil to the spark plugs. The

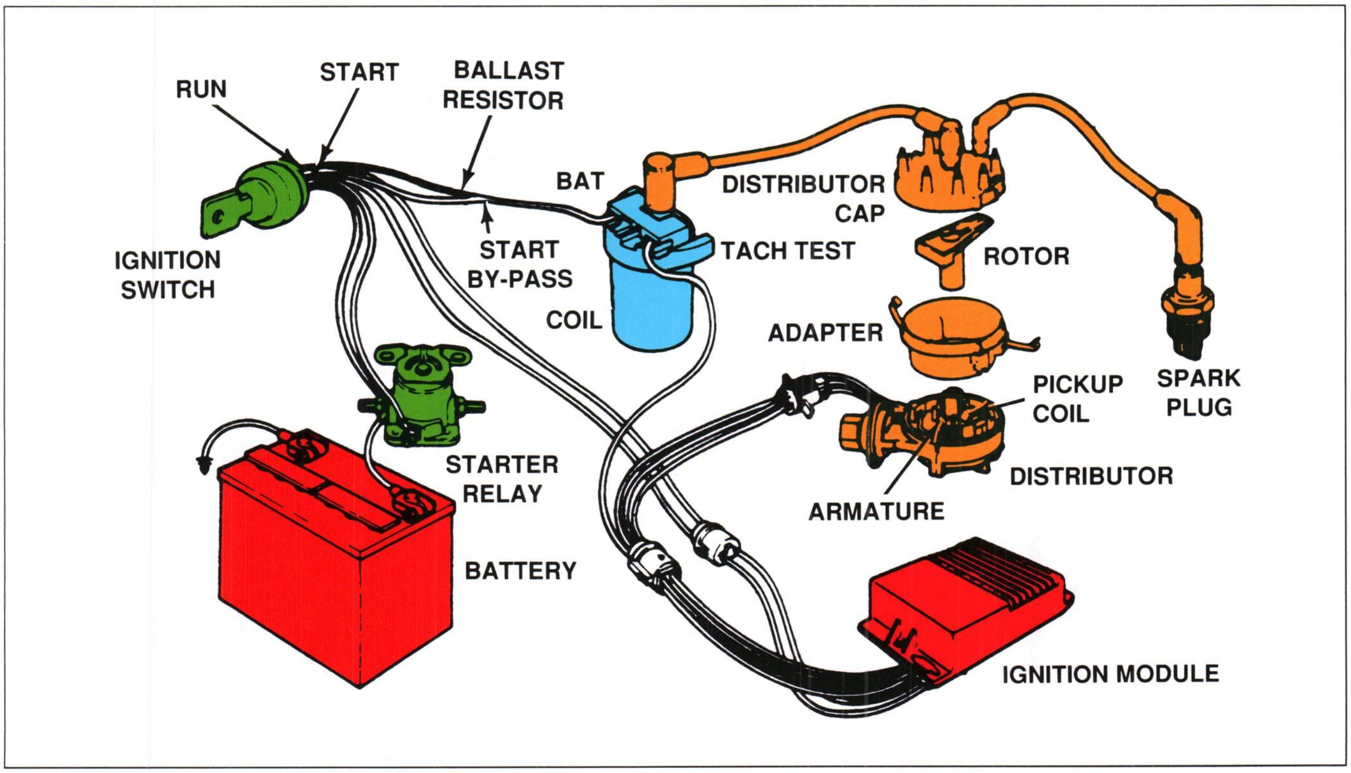
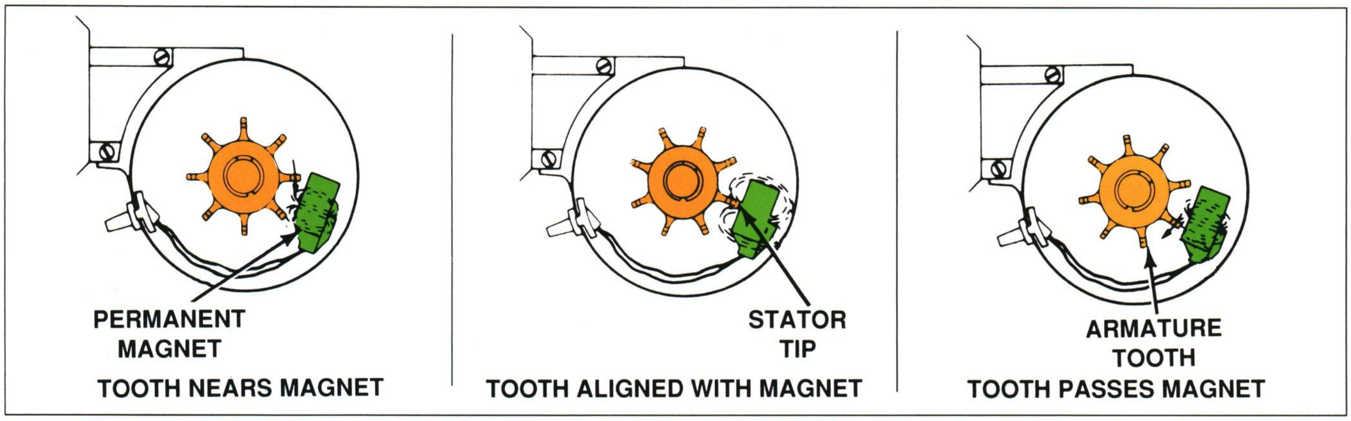


Figure 1-3. Solid-State Ignition System - Duraspark II Shown



TOOTH NEARS MAGNET

TOOTH ALIGNED WITH MAGNET

TOOTH PASSES MAGNET

Figure 1-4. Pickup Coil and Armature Tooth

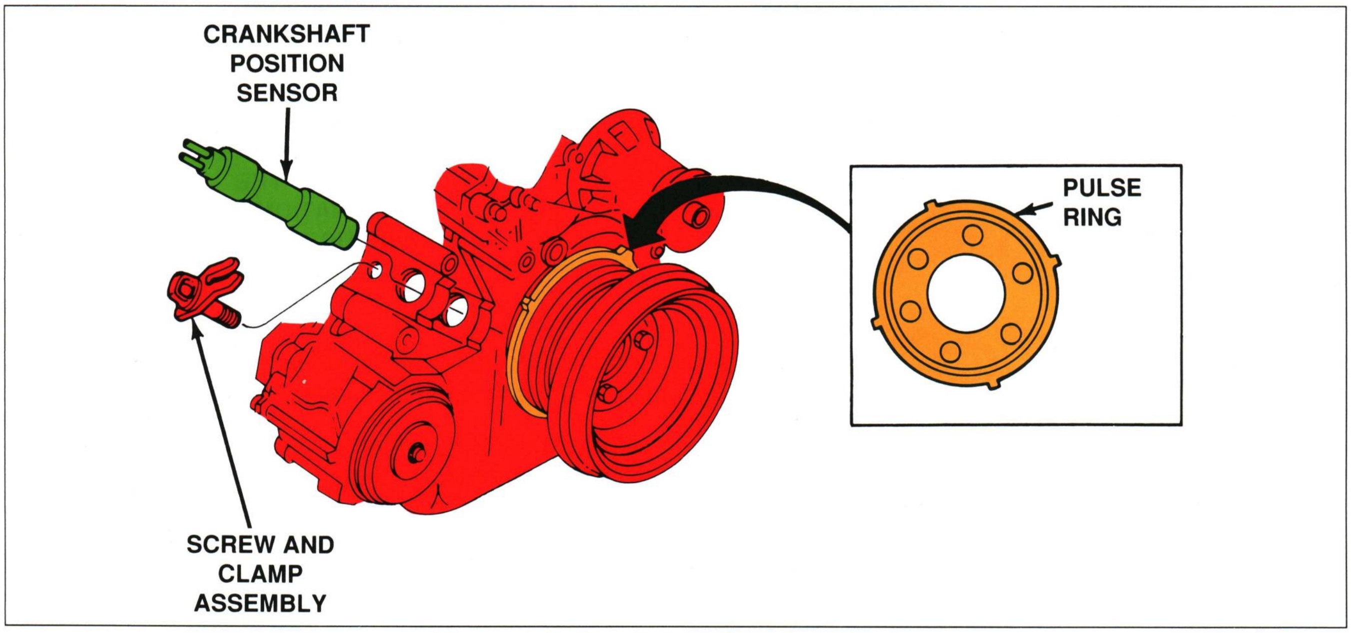


Figure 1-5. Crankshaft Position Sensor

ECA signals when to open the coil primary circuit which generates secondary high voltage at the coil.

Just as the first SSI ignition module was able to determine the correct dwell, so the coil would operate at its most effective firing speed, the new electronic engine controls are able to do the same for engine timing. In the EEC systems, the crankshaft position (CP) sensor provides the timing signal to an electronic control assembly (ECA). The ECA processes this input, plus several others, to determine precisely the right time for the ignition module to send the firing signal to the ignition coil. The ignition module then opens the ground path of the coil primary circuit.

The ignition control signal for Duraspark III ignition modules comes from the EEC microprocessor. Before Duraspark III, this control signal came from the distributor stator assembly.

TFI-I

The Thick Film Integrated-I (TFI-I) ignition system was introduced in 1982 for 1.6L engines. Electronically, its operation is very similar to Duraspark II. One major difference is that the TFI-I module is mounted directly to the base of the distributor assembly (Figure 1-6). A modified pickup coil assembly and armature are used

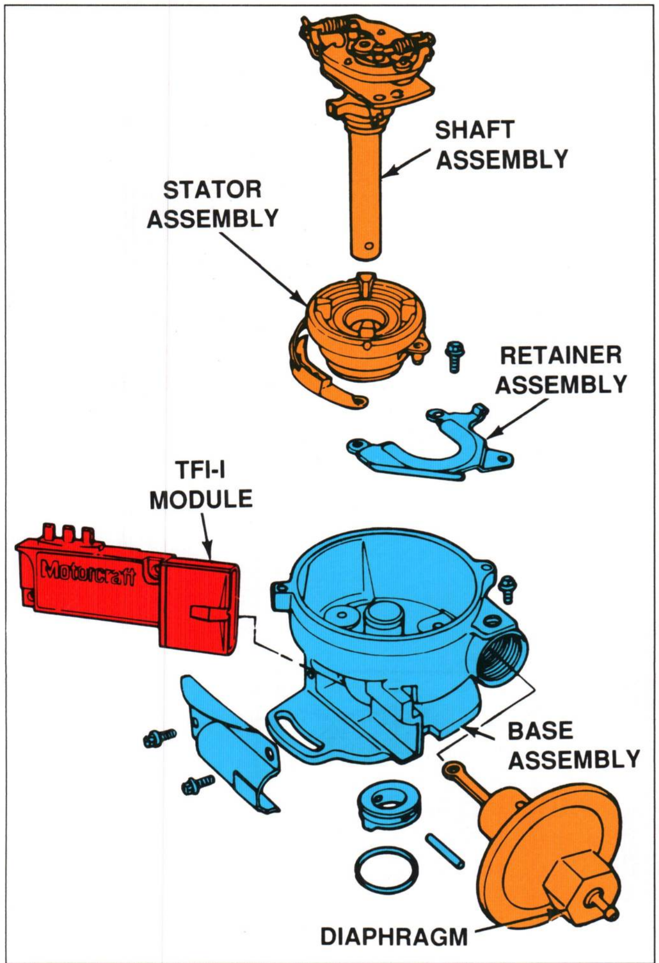


Figure 1-6. TFI-I Ignition Module and Distributor

and the CP sensor is eliminated. Operation remains the same, though more efficient.

Another significant difference between TFI-I and Duraspark is that TFI-I has no ballast resistor. This allows more current to flow, producing a hotter spark. TFI also features a different type of coil, called the E-core coil (Figure 1-7).

The TFI-I system did not have EEC, so the TFI module opened and closed the coil primary circuit. Advance and retard functions were performed by a vacuum controlled diaphragm and centrifugal mechanism, exactly as in the breaker point ignition system.

The Duraspark and EEC-III systems in 1983 were carried over from 1982 and did not change significantly. No major ignition modifications were made. However, the EEC-IV system was first available on the 1983 1.6L engine for Escort/Lynx and EXP/LN7 models. The EEC-IV system is the fifth generation of electronic engine controls (including MCU) released by the Ford Motor Company and is used on most Ford vehicles today.

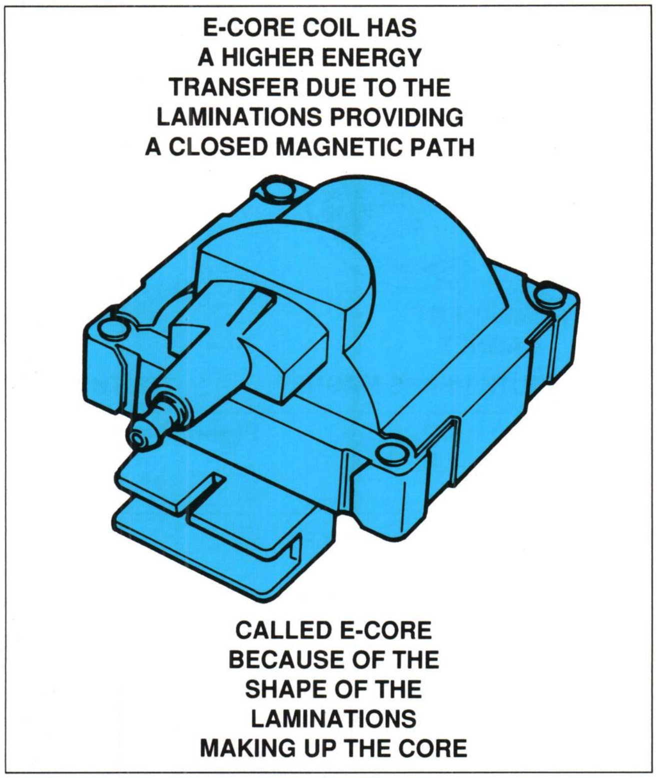

E-CORE COIL HAS A HIGHER ENERGY TRANSFER DUE TO THE LAMINATIONS PROVIDING A CLOSED MAGNETIC PATH
CALLED E-CORE BECAUSE OF THE SHAPE OF THE LAMINATIONS MAKING UP THE CORE

Figure 1-7. E-Core Coil

Like the other EEC systems produced by the Ford Motor Company, the EEC-IV system was developed to provide a better way to control the engine operation rather than by relying on vacuum and mechanical systems alone.

TFI-IV

The TFI-IV module was introduced in 1983 and is used only with the Universal distributor and EEC-IV system. The TFI-IV module is mounted to the Universal distributor in the same manner as the TFI-I module (Figure 1-8).

The Universal distributor contains the PIP (Profile Ignition Pickup) sensor, octane rod, and the Hall effect vane switch stator. A modification to the circuitry of the TFI-IV module provides for push starting. The operation of the Universal distributor is accomplished through the Hall effect stator assembly, causing the ignition coil to be switched OFF and ON by the EEC-IV and TFI-IV modules.

The PIP signal is an indication of crankshaft position and speed (base timing). The PIP signal is sent to the TFI module and to the ECA (Figure 1-9).

The PIP signal is one of many inputs processed by the ECA. The ECA, after taking all the sensor information, produces a new signal called the SPOUT. SPOUT is a digital signal which represents the engine operating condition electronically. SPOUT is sent to the TFI module. The TFI-IV module turns the ignition coil ON. The leading edge of the SPOUT signal turns the ignition coil OFF.

The Universal distributor, unlike the one used with the TFI-I, contains no advance mechanisms and all adjustments of timing and dwell are accomplished electronically. When the correct spark advance is determined, the high voltage spark is distributed through a conventional rotor, cap, and ignition wires.

DIS

For 1989, the Ford distributorless ignition system (DIS) was introduced (Figure 1-10).

DIS eliminates the distributor by using a multiple coil pack. Each coil within the pack fires two spark plugs at the same time. The plugs are paired so that as one fires during the compression stroke, the other fires during the exhaust stroke. The next time that coil is fired, the plug that was on exhaust will be on compression and the one that was on compression will be on exhaust.

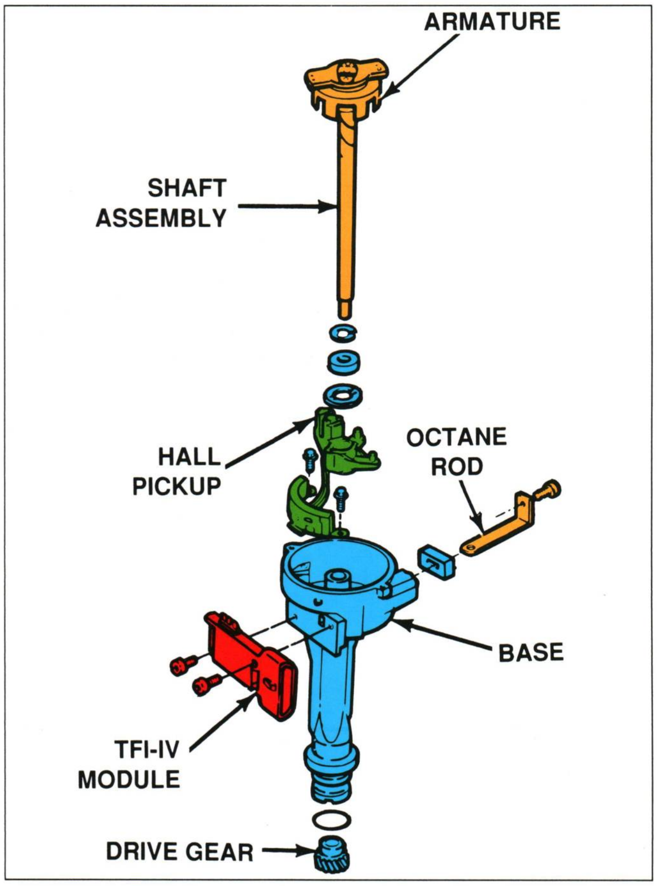


Figure 1-8. Universal Distributor

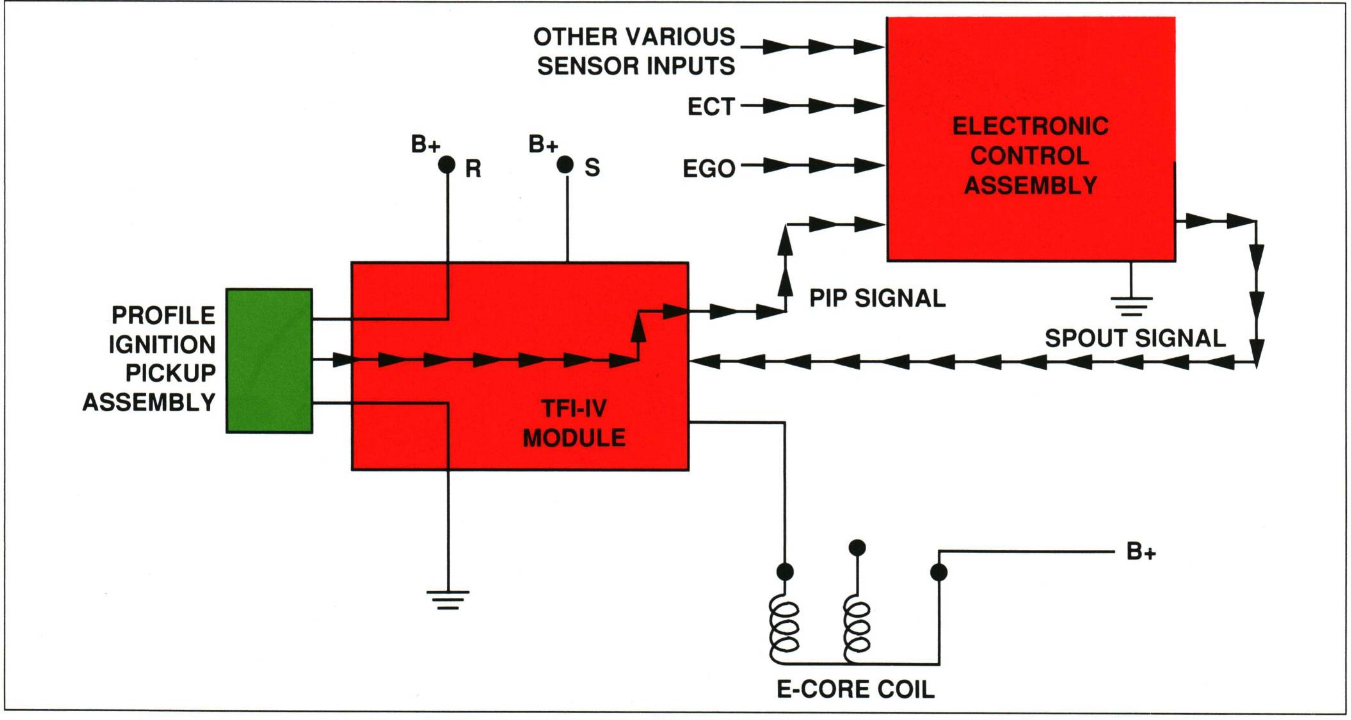

OTHER VARIOUS SENSOR INPUTS
ECT
EGO
B+
R
B+
S
ELECTRONIC CONTROL ASSEMBLY
PROFILE IGNITION PICKUP ASSEMBLY
TFI-IV MODULE
PIP SIGNAL
SPOUT SIGNAL
B+
E-CORE COIL

Figure 1-9. PIP and SPOUT Throughputs

OVERVIEW OF IGNITION SYSTEMS

A PIP sensor is used to indicate the crankshaft position and speed. A cylinder identification (CID) sensor is used to identify a specific point in the travel of piston 1.

The EEC-IV module determines spark angle using the PIP signal to establish base timing. A digital SPOUT signal is sent from the EEC-IV module to the DIS module and serves two purposes: SPOUT fires the coil and controls the dwell time. This feature is called CCD or computer controlled dwell.

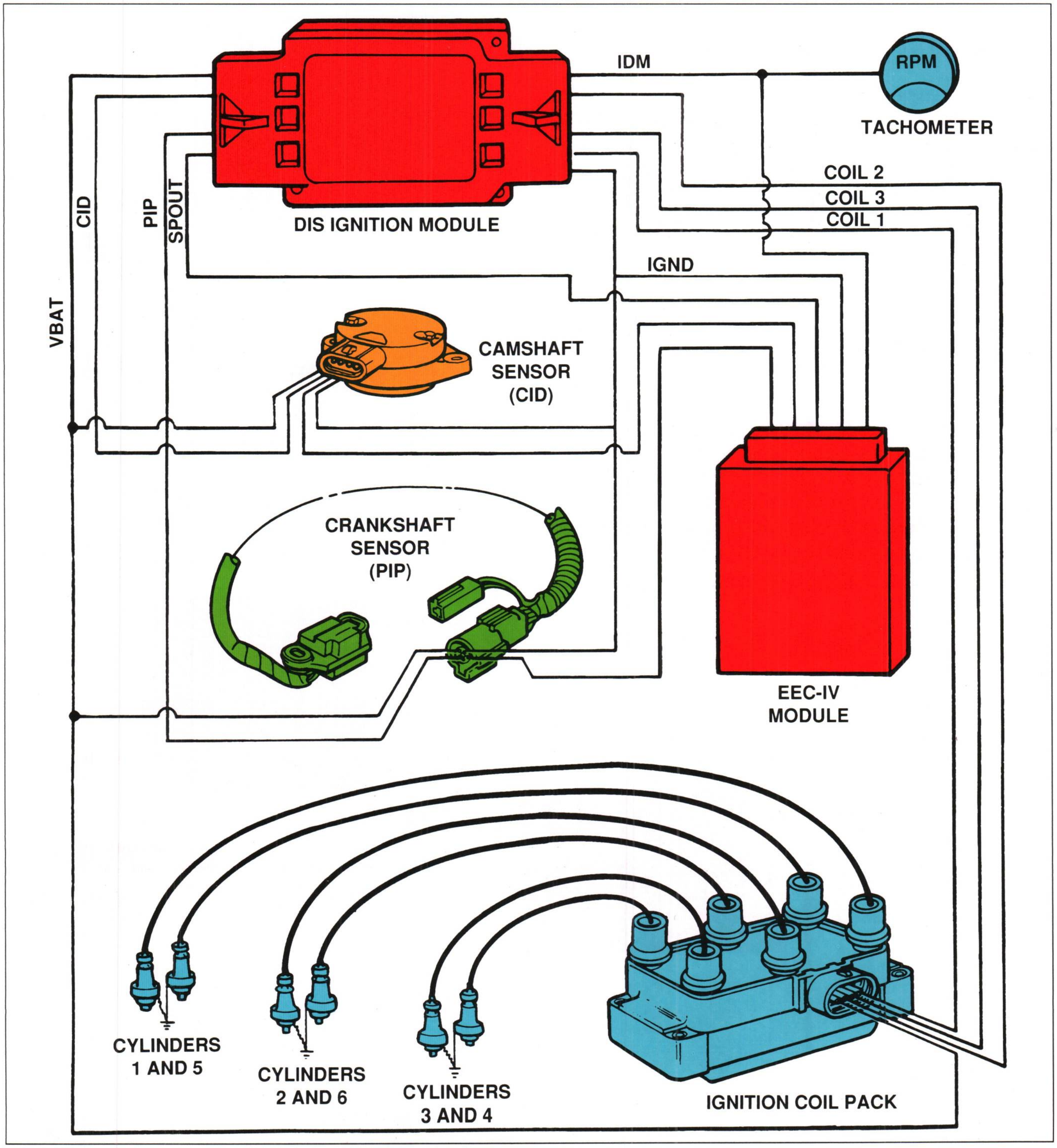


Figure 1-10. Six-Cylinder Distributorless Ignition System

The EEC-IV module determines dwell, or coil ON time. The DIS module controls the current to a particular coil primary circuit and thereby distributes the secondary high voltage to the proper spark plugs.

Similar to the TFI-IV ignition module, a primary function of the DIS ignition module is as an electronic switch for a coil primary circuit. When the switch closes, current flows and a magnetic field expands around the primary coil. When the switch is opened, the field collapses and causes the secondary coil to fire the spark plugs at high voltage.

COMPARING DIS AND TFI-IV

As mentioned, ignition systems are designed to ignite the compressed fuel mixture. The difference is how ignition systems control current in the primary circuit and how the secondary high voltage is distributed to the spark plugs.

Before explaining the details of DIS components and operation, let's take a few minutes to compare DIS and TFI-IV. We will take a quick look at the advantages and features of DIS and then briefly describe the operation of TFI-IV.

FEATURES OF DIS

There are similarities between DIS and TFI-IV; however, many features set DIS apart from previous ignition systems (Figures 1-10 and 1-11).

On DIS, for example:

- initial timing is preset at 10° BTDC and is not adjustable.
- there is no distributor or rotor.
- multiple coils distribute the high voltage to the spark plugs.
  - a coil pack with three coils is used on the six-cylinder 3.8L SC and 3.0L SHO engines.
  - two coil packs, each containing two coils, are used on the 2.3L dual plug engine.
  - each coil within a coil pack supplies the high voltage for two spark plugs.
- two spark plugs are wired in series with each coil secondary winding.
  - each pair of spark plugs is fired at the same time.
  - one plug fires during the compression stroke while the companion plug fires during the exhaust stroke.

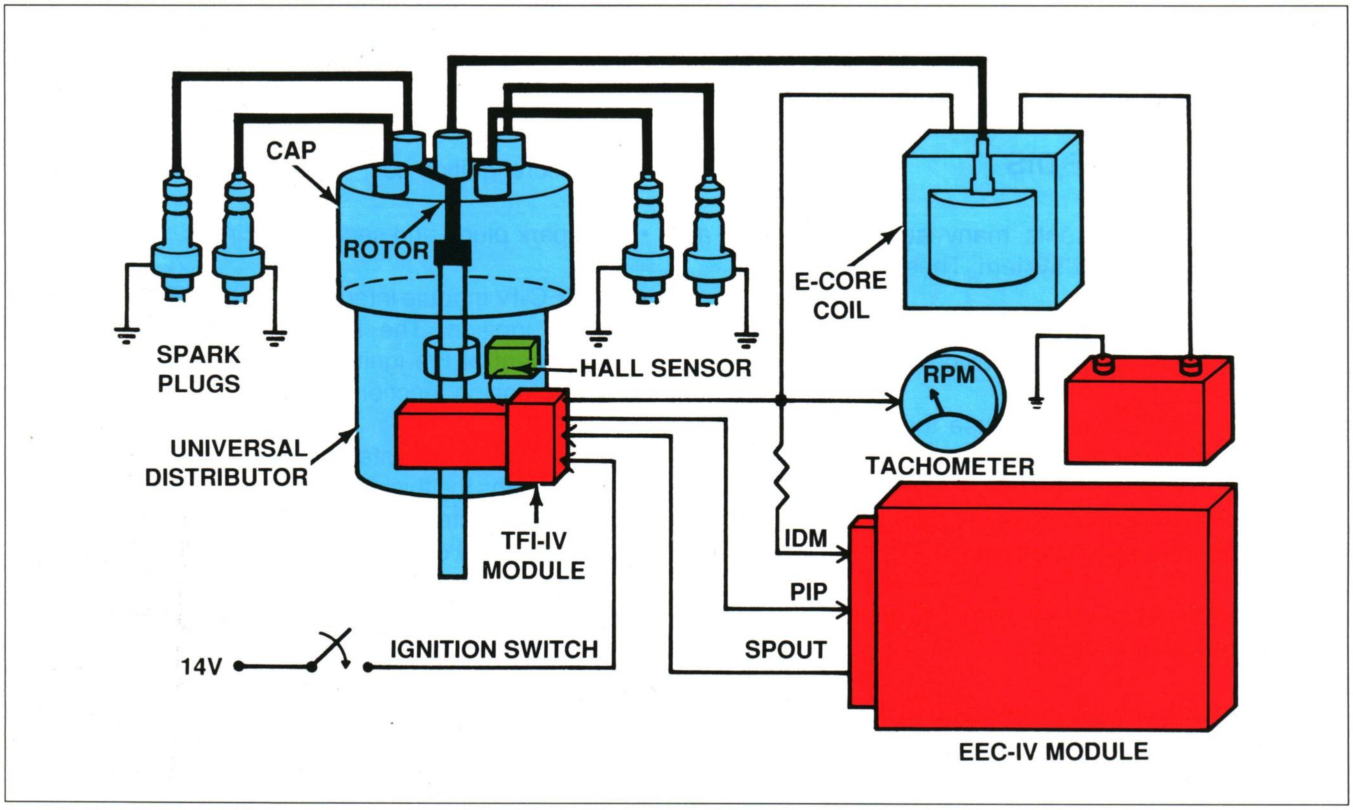


Figure 1-11. Base TFI-IV Ignition System

The next time the coil fires, the plug that was on compression will be on exhaust and the one on exhaust will be on compression.

- a cylinder identification (CID) sensor identifies a specific point in the travel of piston 1.
  - CID is required so DIS knows which coil to fire.
  - on 3.8L SC and 3.0L SHO SEFI engines CID is also used by EEC-IV for fuel control.
- the profile ignition pickup (PIP) sensor is a Hall effect sensor that indicates crankshaft position and speed, as in past ignition systems. However, for DIS, the PIP sensor is mounted at the crankshaft.
- the DIS module is a logic module that selects the proper coil, then fires that coil based on EEC-IV input. Although it's an integrated thick film design like TFI-IV, the DIS module performs different functions than the TFI-IV module.
- the EEC-IV module incorporates a feature called computer controlled dwell (CCD). CCD uses SPOUT to say when a primary circuit should be energized and to control dwell.

The details of the functions and operations of these features are explained later in "DESCRIPTION OF DIS" and "DIS OPERATION."

ADVANTAGES OF DIS

The DIS system presents many advantages over a conventional distributor system. These include:

- improved reliability because the system is solid-state. There is less friction from moving parts.
- reduced maintenance because there is no cap and rotor to service or replace.
- no underhood spark across the rotor gap, resulting in less radio frequency interference.
- no need for timing adjustment since there is a crankshaft ignition pickup.
- precise spark control, allowing up to 3 to 4 degrees of additional spark advance.
- reduced quits on road through inherent DIS design redundancy. That is, there are two coils and two ignition output drivers on a typical four-cylinder system.
- elimination of ozone/nitric acid and water buildup in distributor cap, causing misfire or no start conditions.
- elimination of one of the five high voltage wires (coil suppressor lead) on a typical four-cylinder application.
- elimination of the distributor weather boot.
- improved packaging flexibility because DIS uses less space. This is a factor in designing engines for today's smaller engine compartments.

TFI-IV OPERATION OVERVIEW

Before the introduction of DIS, all EEC-IV vehicles were equipped with a thick film integrated ignition system, generation four, which is commonly called TFI-IV (Figure 1-11). The components of the TFI-IV ignition system include:

- the TFI-IV ignition module.
- a Universal distributor.
- a Hall effect PIP sensor within the distributor.
- an E-core ignition coil.
- the spark plugs and secondary circuit.
- the EEC-IV module interacts with the TFI-IV module to control ignition. The EEC-IV module is not just a component of the ignition system, but does perform certain ignition functions.

The TFI-IV ignition system uses a Universal distributor which contains the thick film ignition module, and the Hall effect vane switch stator. No centrifugal or vacuum advance is used on this distributor.

The Hall effect vane switch stator provides an input to the signal processor in the TFI-IV ignition module. From this input, TFI-IV provides a digital PIP signal to the EEC-IV module. The PIP signal is an indication of the crankshaft position and engine speed (RPM).

OVERVIEW OF IGNITION SYSTEMS

TFI-IV uses the RPM information to determine when to turn ON the primary circuit of the E-core ignition coil. An output driver in the TFI-IV module completes the ground path of the coil primary circuit. As current begins to flow in the coil primary circuit, a magnetic field expands around the primary and secondary coils. When the primary coil reaches its maximum charge, the magnetic field stabilizes. However, current continues to flow until the coil primary circuit is opened by the TFI-IV module based on the SPOUT signal.

The EEC-IV module determines the desired spark angle based on sensor input, strategy, calibration and adaptive learning. EEC-IV then sends a SPOUT signal to the TFI-IV module to fire the coil.

An output driver in the TFI-IV module opens the coil primary circuit. The magnetic field collapses and current is induced in the secondary circuit. The current flows through the rotor in the distributor and is directed to the correct spark plug. A high voltage spark jumps the gap of the plug to ignite the compressed fuel mixture.

As you can see, TFI-IV uses past engine speed information to control dwell, or coil ON time. EEC-IV determines spark angle and uses SPOUT to signal TFI-IV to turn the coil OFF. On DIS though, the CCD feature of EEC-IV uses SPOUT to signal the DIS module to turn a coil ON and turn that coil OFF.

In a four-cycle engine, the camshaft rotates at half the crankshaft speed. This means that for TFI-IV, each cylinder fires once for every two revolutions of the crankshaft. On a six-cylinder engine, six spark plugs fire for every two revolutions of the crankshaft. Therefore, the E-core coil is turned ON and OFF three times per crankshaft revolution (Figure 1-12).

On DIS six-cylinder engines, all the spark plugs fire during one revolution of the crankshaft. This is because the spark plugs are fired in pairs. However, since there are three coils within a coil pack, each coil is turned ON and OFF once per crankshaft revolution. This allows for increased dwell and reduced stress on the coils.

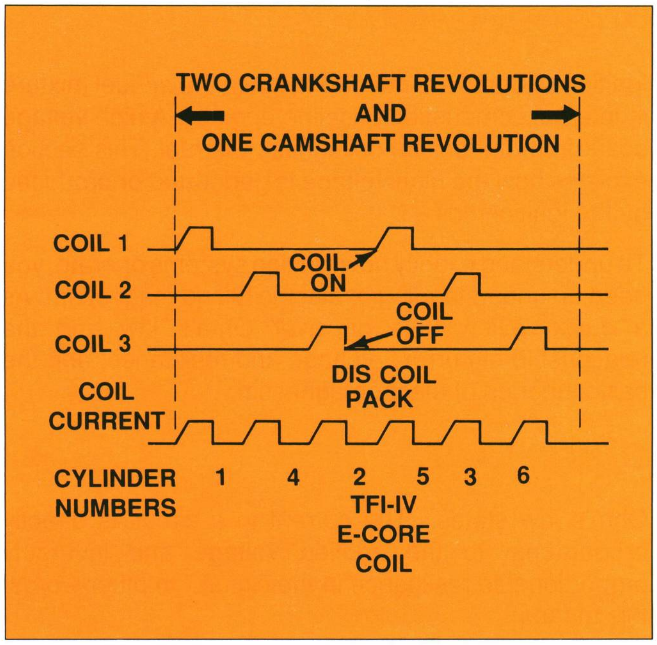


Figure 1-12. Firing Coils - DIS and TFI-IV

Coil current is controlled electronically by the ignition module.

On TFI-IV systems, if the SPOUT signal line opens from the EEC-IV module, TFI-IV uses the PIP signal to fire the coil. This results in spark timing at base (initial). The DIS module also fires the coils from PIP if SPOUT opens. This too results in a fixed spark angle and fixed dwell.

Of course this description of TFI-IV operation is just an overview. For additional information about TFI-IV, ignition systems, and electronic engine control, review the "SUGGESTED PUBLICATIONS" listed in this section.

The next section of this text, "FUNDAMENTALS OF IGNITION SYSTEMS," provides details of the principles of operation of ignition systems.

FUNDAMENTALS OF IGNITION SYSTEMS

INTRODUCTION

Ignition systems are needed to ignite the air/fuel mixture in internal combustion gasoline engines. A high voltage spark from an ignition coil ignites the fuel. This section explains how the high voltage is generated or produced by the ignition coil.

To understand exactly how ignition systems operate, you need an understanding of electricity and magnetism. As a quick review, lets go over Ohm's law and the relationship of current, voltage and resistance, and the basic theories of electromagnetism.

OHM'S LAW

Ohm's law states, "The current in a circuit is directly proportional to the applied voltage and inversely proportional to resistance in the circuit." In other words, this means:

- when voltage goes down, current does down in the same proportion, if the resistance stays the same. If voltage is halved, current is halved.
- when voltage goes up, current flow goes up in the same proportion, assuming the resistance stays the same. If voltage is doubled, current is doubled.
- when resistance goes up, current goes down in inverse proportion, if the voltage stays the same. If resistance is doubled, current is halved.
- when resistance goes down, current goes up in inverse proportion, assuming voltage stays the same. If resistance is halved, current is doubled.

Expressed as equations, Ohm's law shows current flow (I) equals voltage (E) divided by resistance (R): I = E/R, or E = I times R, or R = E divided by I (Figure 2-1).

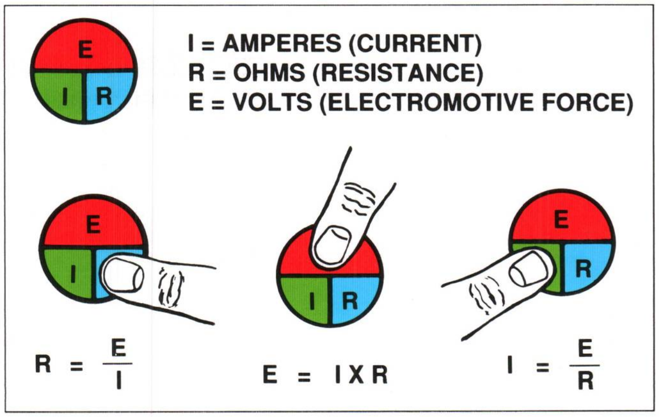


Figure 2-1. Ohm's Law

CONDUCTORS

Current flow takes place in substances called conductors. The movement of electrons along a conductor, that is, current flow, is measured in amperes. Current flow is directly related to the voltage applied to the conductor.

RESISTANCE

Resistance is the opposition offered by a conductor to a flow of electricity. All conductors have a certain resistance to current flow. Resistance is measured in ohms.

INSULATORS

Insulators are the opposite of conductors, therefore, it is difficult or impossible to cause a current flow in insulators.

ELECTROMOTIVE FORCE

Electromotive force (EMF), or voltage, is required to cause current flow. EMF is measured in volts and refers to the electrical pressure causing the electrons to flow in a conductor. By the way, this energy, or current, travels at the speed of light; 186,000 miles per second.

EMF is generated in many ways such as friction, chemical, heat, light, pressure, or magnetism. For example, chemical action of the battery generates the EMF needed to crank the engine and energize the coil at start-up. Magnetism is then used within the coil to generate the high voltage required for spark.

ELECTROMAGNETISM

Automotive coils and alternators are examples of electromagnetic induction. In order to induce current in this way, either the magnetic field or the conductor must be moving. In other words, there must be relative movement between the magnetic field and the conductor. The conductor can be moving through the stationary magnetic field; or the magnetic field can be moving across a stationary conductor; or the magnetic field can be expanding or collapsing through a conductor.

In generators, current is induced as the conductor rotates within a stationary magnetic field. In automotive alternators, the magnetic field rotates within a stationary conductor. A magnetic field expands and collapses through the conductor to induce current in automotive coils and step-up or step-down transformers (Figure 2-2).

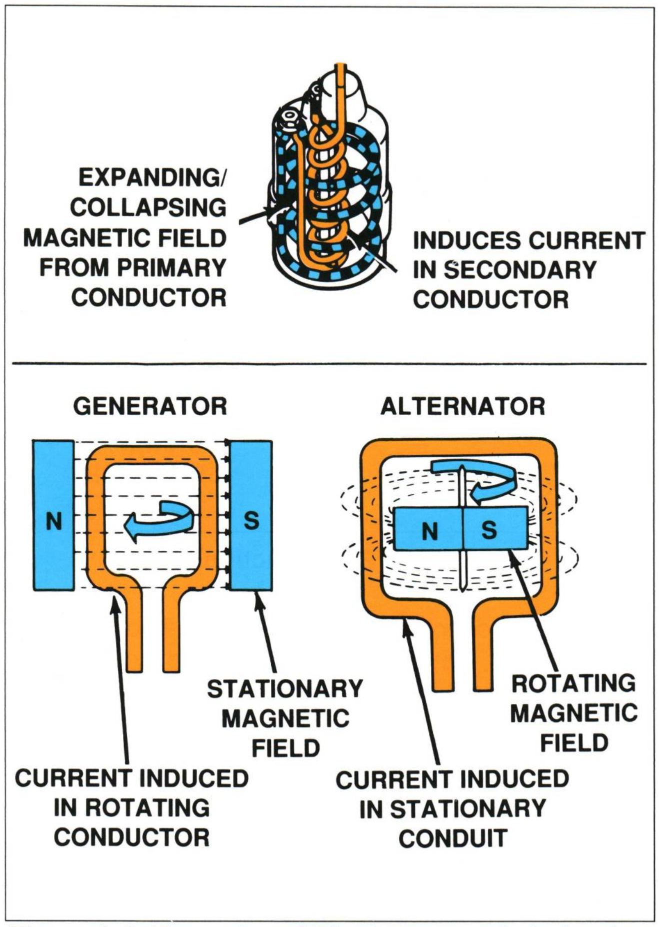


Figure 2-2. Examples of Electromagnetic Induction

As you know, electron flow is current. Current flowing through a conductor causes a magnetic field around that conductor. Electromagnetism is the magnetic field produced by a conductor carrying an electric current.

This electromagnetic field has force and direction. You can use the left-hand rule to determine the direction of the magnetic field around a conductor carrying current. Imagine the conductor in your left hand with your thumb pointing in the direction of the electron flow. Note that electrons flow from negative to positive. Your fingers will circle the conductor in the same direction as the magnetic lines of force (Figure 2-3).

This magnetic field expands rapidly, but certain forces do affect how rapidly. One force that opposes the expanding magnetic field is caused by the expanding field. This type of opposition is called inductive reactance. Another force is due to the design, construction, and material of the coil and is known as inductive reluctance.

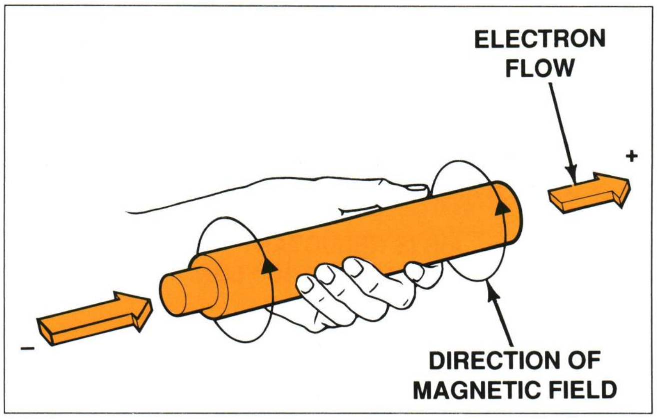


Figure 2-3. The Left-Hand Rule

INDUCTIVE REACTANCE

Current flowing through a coil causes a magnetic field. As this magnetic field starts to expand, a small opposing electromotive force is induced in the next loop of the coil. This small EMF flows against or impedes the current. This opposition is called inductive reactance. In other words, inductive reactance is the opposition to a change in a current, either an increase or decrease, in the windings of a coil (Figure 2-4).

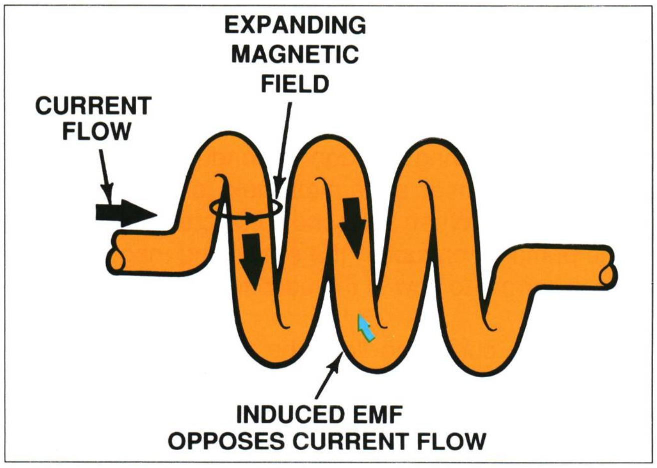


Figure 2-4. Inductive Reactance

INDUCTIVE RELUCTANCE

Just as there are materials that resist the flow of electrical current, some materials are reluctant to pass magnetic lines of force, or flux. The magnetic materials used in the core of a coil will affect the rate at which the magnetic field expands. The construction of a coil also affects the rate of expansion. This resistance to the magnetic lines of force is inductive reluctance (Figure 2-5). Air has high reluctance, while soft iron has low reluctance. To reduce the reluctance of the DIS coil for example, a silicon steel core is used.

▷ ▷ RELUCTANCE FROM AIR AND COIL MATERIALS

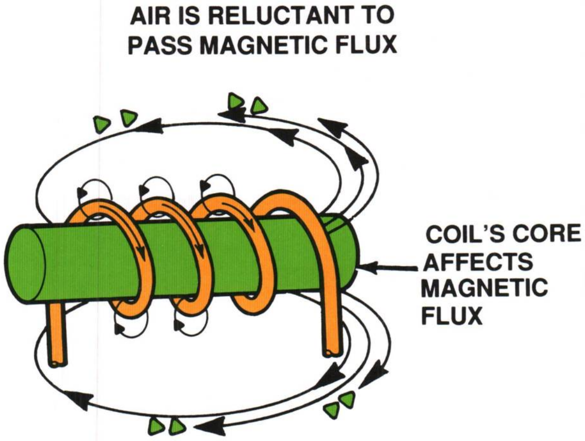

AIR IS RELUCTANT TO PASS MAGNETIC FLUX
COIL'S CORE AFFECTS MAGNETIC FLUX

Figure 2-5. Inductive Reluctance

INDUCTANCE

Inductance is the property of an ignition coil that allows electrical energy to be transferred from the primary coil to the secondary coil.

The current flowing through a conductor, such as a primary coil, causes a magnetic field to expand around that conductor. When a second conductor is placed next to the primary conductor, the expanding magnetic field causes current to flow in the secondary conductor.

To induce a current to flow, the secondary conductor must be within the magnetic field of the primary conductor and the magnetic lines of force must be moving through the secondary conductor. That is, the magnetic lines of force, or flux, must be expanding or collapsing through the secondary conductor in order to induce a current. Also, the current induced in the secondary conductor flows in the opposite direction of the primary current. The process of generating electric current in this way is called induction (Figure 2-6).

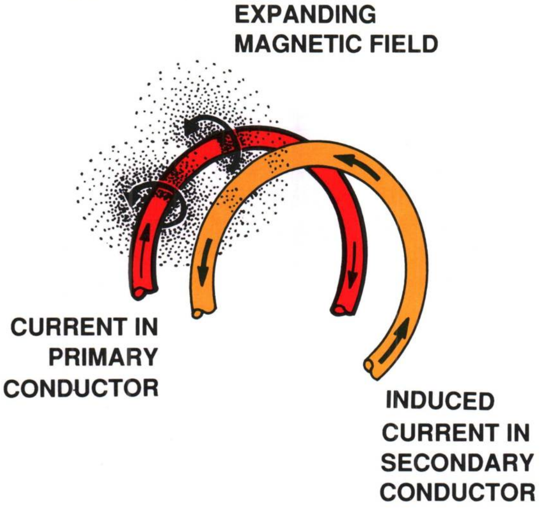

EXPANDING MAGNETIC FIELD
CURRENT IN PRIMARY CONDUCTOR
INDUCED CURRENT IN SECONDARY CONDUCTOR

Figure 2-6. Induction

Since current is flowing in the secondary conductor, a magnetic field is produced. The direction of the secondary magnetic field opposes or moves in the opposite direction of the primary magnetic field. The direction and force of the induced current depend on the strength and direction of the magnetic field from the primary circuit. Induction can be improved by improving the magnetic field surrounding the conductor.

REMEMBER THE FOLLOWING:

- current flow through a conductor produces a magnetic field around that conductor.
- force and direction of the magnetic field is affected by the design, construction, and materials used in the coil, and the expanding field itself.
- when a magnetic field expands or collapses through a conductor, a current will be induced in that conductor.
- the current induced in the second conductor flows in the opposite direction of the primary current.

COILS

When a conductor is formed into a coil, the magnetic field is many times stronger than that of a single straight conductor (Figure 2-7). Furthermore, to increase the strength of the magnetic field, increase the number of loops in the coil, or increase the amount of current flowing in a coil, or use a low reluctance material for the core of the coil (Figure 2-8).

As mentioned earlier, if a coil is placed near a second coil, and the first coil is connected to a current, the expanding magnetic field induces a current into the second coil (Figure 2-6). The current induced into a coil is much

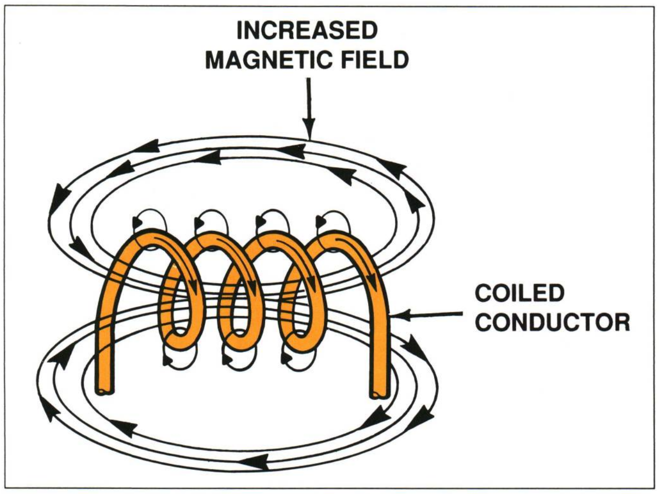


Figure 2-7. Conductor Formed into a Coil

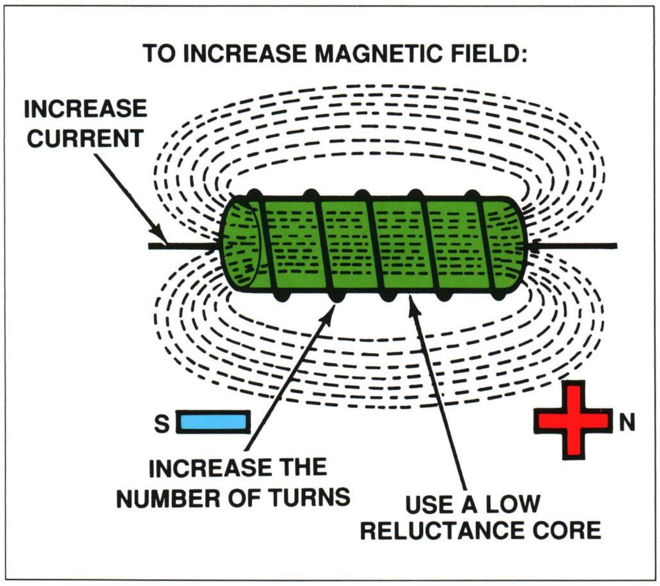


Figure 2-8. Increasing Magnetic Field

higher than a current induced into a straight conductor. As you know, the coil which carries the current into this type of inductance system is the primary winding of the coil. The coil into which the EMF is induced is the secondary winding of the coil. This mutual induction is the principle behind the automotive ignition coils, alternators and transformers (Figure 2-9).

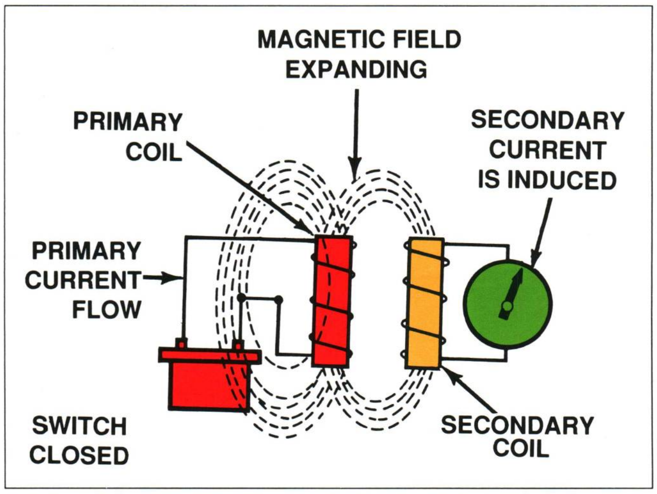


Figure 2-9. Inductance Between Coils

Keep in mind that the magnetic field must be moving in order to induce a current. Once the magnetic field has stabilized and is not expanding through the secondary conductor, there is no current induced in the secondary conductor. As the field collapses, the lines of force once again pass through the secondary windings, now inducing a current in the opposite direction. When the field has completely collapsed, the current flow in the secondary conductor stops (Figure 2-10).

MAGNETIC FIELDS

It is the moving magnetic field, or flux, that induces a current. Increasing the strength of the magnetic field increases the current induced. This means the amount of flux from the primary coil affects the amount of current induced in the secondary coil.

As we discussed, to increase the strength of the magnetic field, or flux, in the primary coil:

- increase the number of turns in the primary coil winding.
- increase the current flowing in the primary coil.
- use a material for the core of the primary coil that has a low reluctance value.

Just as certain factors affect the amount of flux generated by the primary coil, there are factors that affect the voltage from the secondary coil. The amount of secondary voltage that is generated depends on the amount of flux, the number of turns in the secondary coil, and the speed at which the primary current is interrupted.

The amount of flux, of course, depends on the primary current. More current means more flux. The flux moves through the windings of the secondary coil. More turns in the secondary coil than in the primary coil results in more

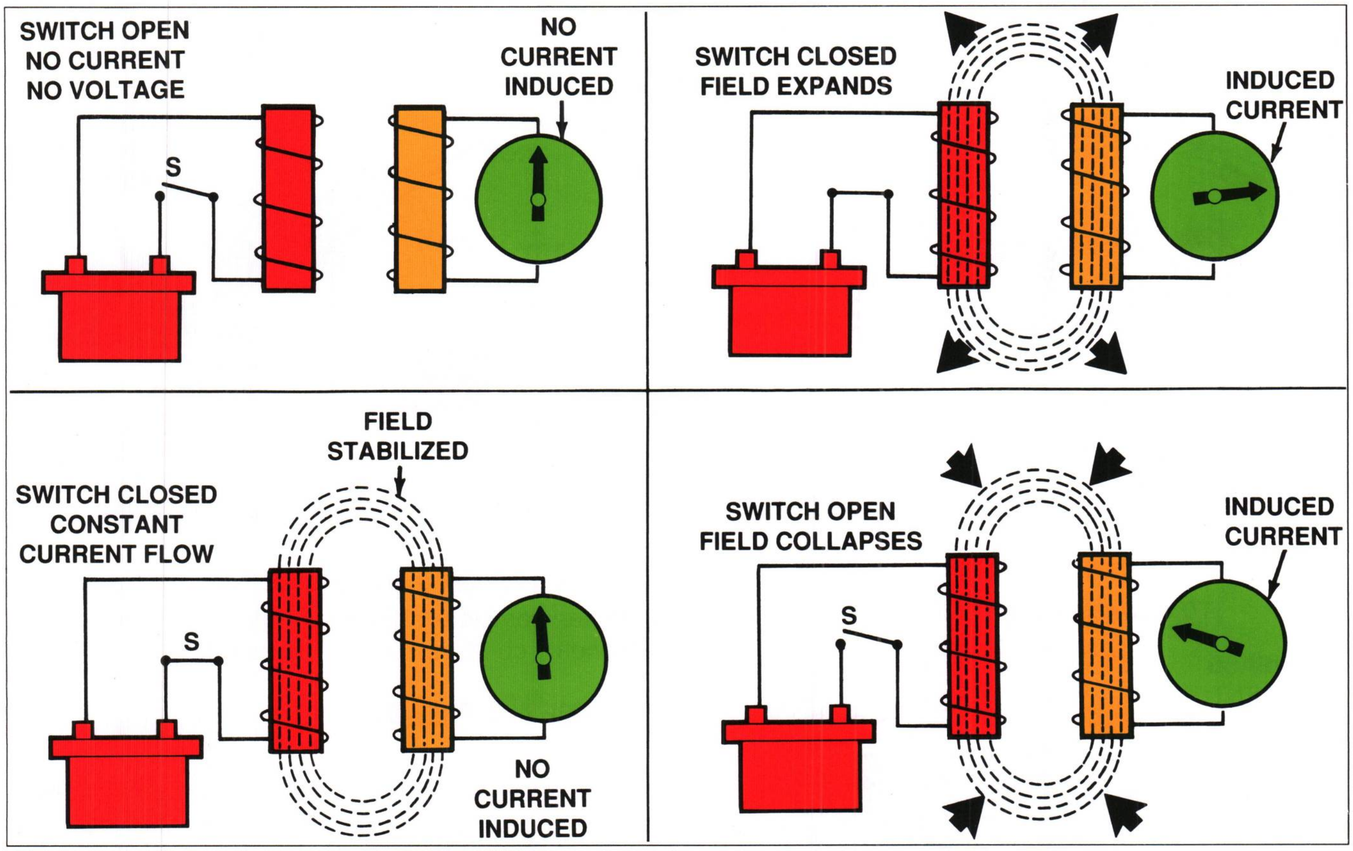


Figure 2-10. Inducing Current in Secondary Coil

voltage from the secondary coil. Flux collapses through the secondary coil when the primary current is interrupted. A quick interruption causes the flux to cut through the secondary windings faster. A quicker interruption results in more secondary voltage than a slow interruption.

FLUX EXPANDS SLOWLY; COLLAPSES QUICKLY

The magnetic field expands slowly compared to how quickly the field collapses. The rate at which the magnetic field changes is slow when the coil is turned ON. This is due to inductive reactance of the primary coil. The slow rate of change means the flux cuts through the secondary coil slowly. The secondary voltage is low. The low voltage can't overcome the resistance of the spark plug gap. No spark is produced as the magnetic field expands.

When the coil is turned OFF, the rate at which the magnetic field changes is fast. DIS, for example, uses output drivers to open the primary circuits. Since each output driver is a transistor, or solid-state switch, the primary circuit opens almost instantly. The flux collapses quickly and the high voltage induced in the secondary circuit jumps the gap of the spark plug.

It is interesting to note that a voltage kick back results when current to the primary coil is interrupted. The DIS ignition module uses this voltage spike to generate an IDM signal.

As mentioned, one way to increase the strength of the magnetic field is to increase the number of loops or turns in the coil. If the number of turns in the primary and secondary coil is the same, the ratio of voltage and current in the two coils is one-to-one (1:1) (Figure 2-11). As the number of turns in the secondary coil increases, voltage increases but amperage decreases. The coils within a DIS coil pack have about 280 secondary turns for each primary turn, or a ratio of 1:280.

POWER IN EQUALS POWER OUT

A basic law of physics is that energy cannot be created or destroyed. That means whatever energy we put into the first coil will come out of the second coil, as long as the transformer is 100% efficient. The DIS coil packs, for example, are about 98% efficient.

The ratio of the number of turns in the primary and secondary coils determines the amperage and voltage

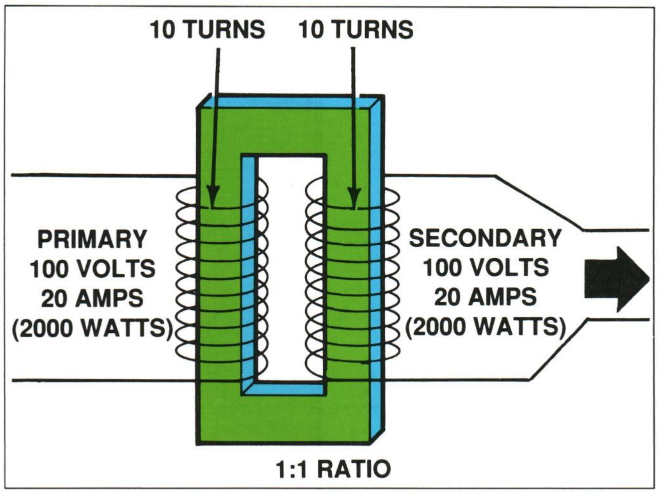


Figure 2-11. Voltage to Amps Ratio Depends on Turns in Coils

induced in the secondary coil. The ratio between the primary and secondary voltages is the same as the ratio between the number of turns of wire in the primary and secondary coils. The ratio between the primary and secondary currents (amperage), however, is the inverse of this winding ratio.

For example, let's say the primary coil has 10 turns and the secondary coil has 100 turns. The number of windings from the primary coil to the secondary coil increased 10 times, or a 1-to-10 ratio. Voltage in the secondary coil will also increase 10 times, 1-to-10 ratio. Current flow, however, decreases 10 times for a 10-to-1 ratio.

Applying 100 volts to the primary coil in this example results in 1000 volts in the secondary coil. However, in this example, the 20 amps in the primary coil are reduced to 2 amps in the secondary coil. Notice that the amount of energy, or watts, remains the same (Figure 2-12).

POWER

Energy can be expressed as power. Power in electrical terms is watts. Watts equal volts times amperes, or W=EI.

In our example, the primary coil current is 20 amps with 100 volts. Using Ohm's law, we can determine resistance in the primary circuit is 50 ohms. The amount of power is 2000 watts, that is, 100 volts times 20 amps.

The secondary coil has 2 amps with 1000 volts. This means resistance in the secondary circuit is 500 ohms.

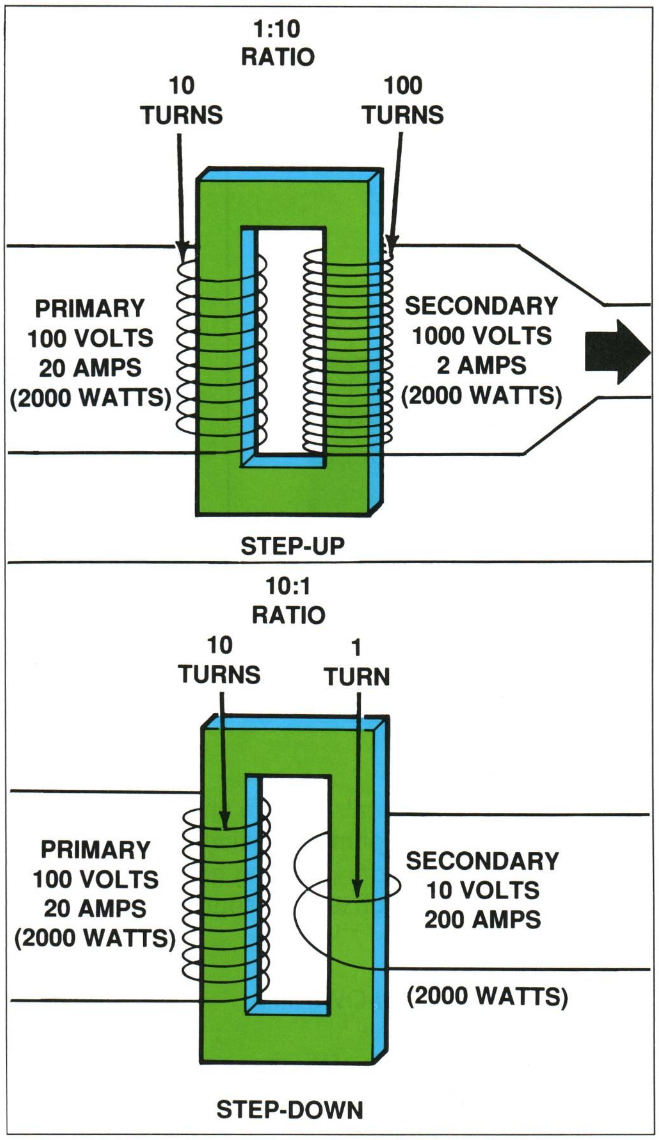
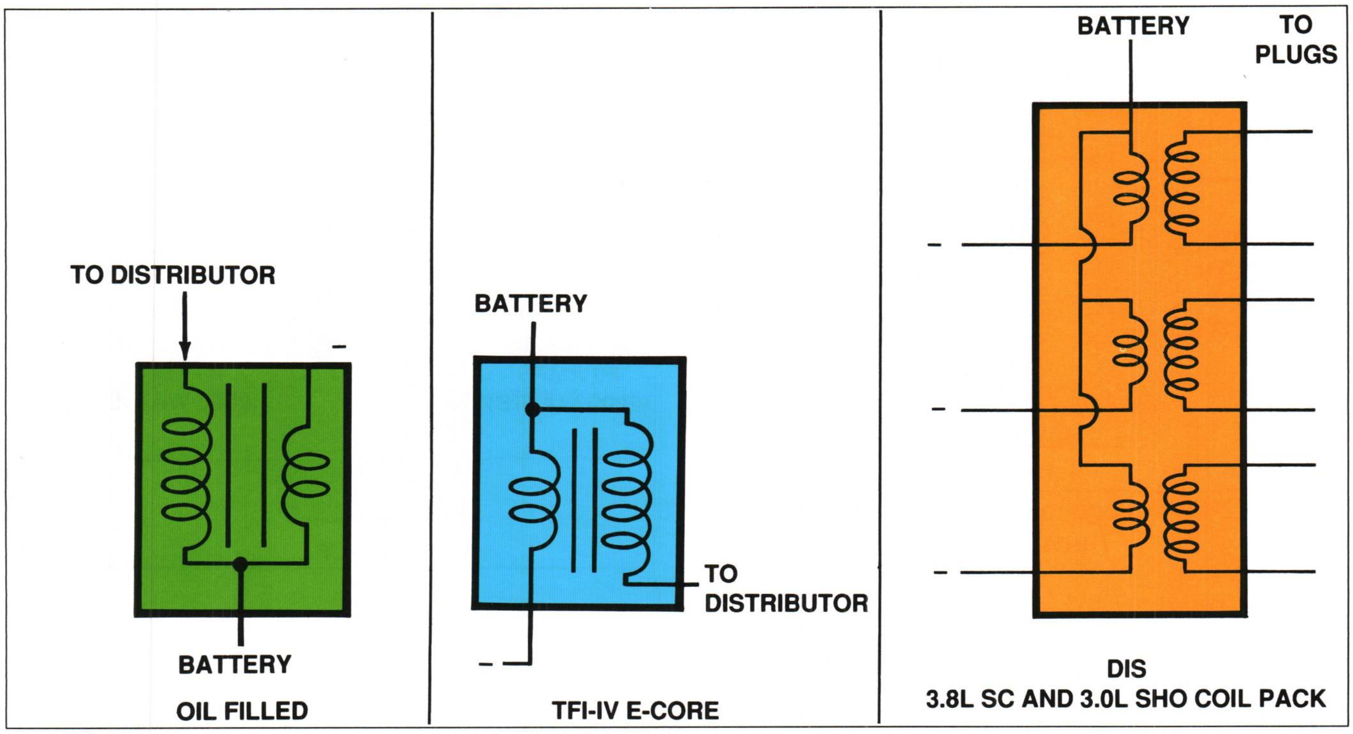


Figure 2-12. Step-Up and Step-Down Transformers

The amount of energy is still 2000 watts, that is, 1000 volts times 2 amps.

The ignition coil is a voltage step-up transformer that raises the vehicle voltage to upwards of 40,000 volts to jump the gap in the spark plugs. As a comparison, the average bolt of lightning is 70,000 volts.

Several types of ignition coils are in use today (Figure 2-13). The DIS coil pack, the TFI-IV E-core coil, and, of course, the oil filled coil. Note that the secondary circuit of the DIS ignition coil is wired in series. The E-core coil used in the TFI-IV ignition system, by comparison, has a primary and secondary winding wound on the same core,



OIL FILLED

TFI-IV E-CORE

DIS
3.8L SC AND 3.0L SHO COIL PACK

Figure 2-13. Ignition Coils

with one common terminal. The two ends of the primary winding connect to the primary ignition circuit, while the open end of the secondary winding goes to the center tower of the coil. The high tension spark lead is plugged into the coil tower.

REMEMBER THE FOLLOWING:

- to increase the strength of the magnetic field, or flux, of a primary coil;
  - increase the number of turns in the coil.
  - increase the current flowing in the coil.
  - use a low reluctance material for the core of the coil.
- the amount of secondary voltage depends on;
  - the amount of primary current.
  - the number of turns in the secondary coil.
  - how quickly the primary current is interrupted.
- the power output of the secondary coil closely equals the power input to the primary coil.

DWELL

A specific amount of time is needed for a coil primary circuit to reach its current limiting area. From the time the primary circuit is energized, the magnetic field expands until this current limit is achieved. Then the magnetic field stabilizes. The time required is about 3 milliseconds for DIS coils. This time must be considered in order to accurately determine dwell to advance or retard ignition timing.

Dwell is the length of time that current is flowing in the coil primary circuit. Dwell includes the time required for the coil to obtain its maximum charge plus the time until current flow is interrupted. After a coil reaches its current limiting area, or maximum charge, current continues to flow through the coil primary circuit. However, the magnetic field stabilizes and no additional power is stored in the coil primary circuit (Figure 2-14).

The EEC-IV module determines dwell based on sensor inputs, strategy, calibration, and adaptive learning. EEC-IV then sends a digital SPOUT signal to the ignition module. TFI-IV ignition modules turn the coil primary circuit ON and use SPOUT to fire the coil. DIS ignition modules, however, open and close a coil primary circuit based on SPOUT.

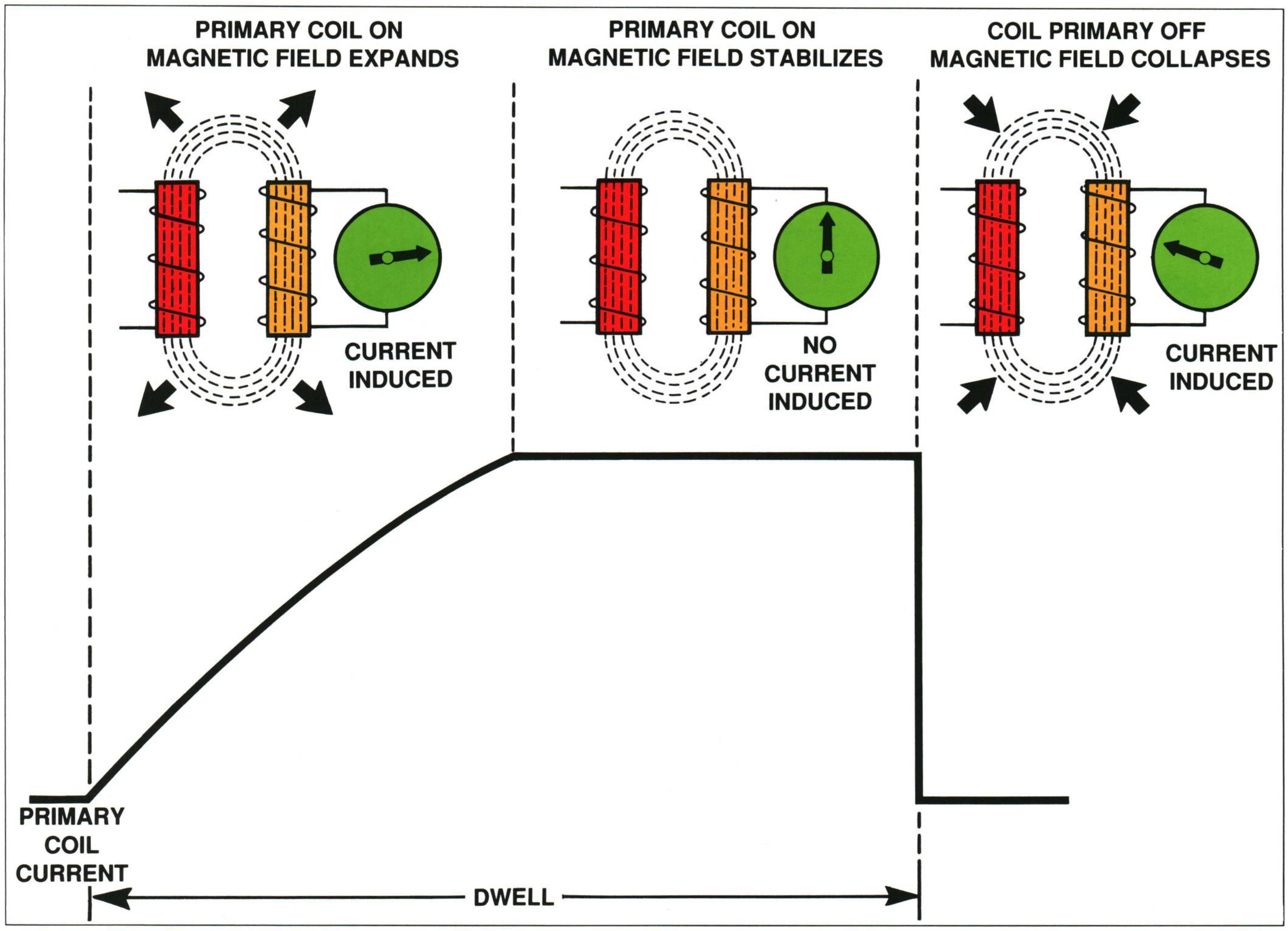


Figure 2-14. Dwell

COIL PROTECTION

To avoid damage, ignition coils must be protected from electrical overloads.

Coil protection is provided by several methods, depending on the ignition system and the type of coil.

Several types of coils are being used. One is the oil filled coil, which has been in existence for many years. Another is the E-core coil, which has laminations like a transformer and is potted in plastic. The E-core coil is used in TFI-IV ignition systems.

DIS uses coil packs. This ignition coil is a closed magnetic core type with one primary winding for every two high voltage outputs. Each coil directly supplies secondary voltage for two spark plugs.

CURRENT LIMITING

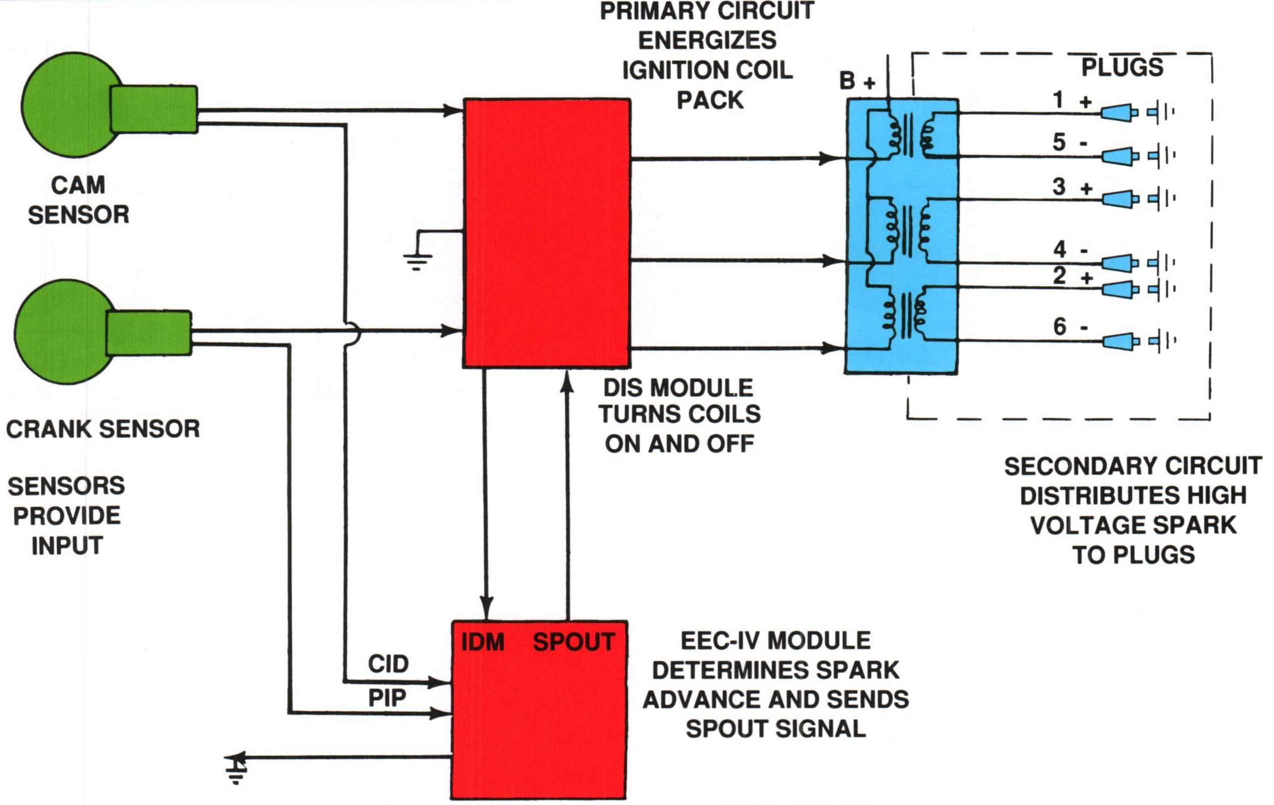
The TFI-IV ignition coil current is limited to 5.5 amps or 6.5 amps (± 0.5 amps), depending on the ignition system.

DIS coil primary current is limited to 5.5 amps (± 0.5 amps). DIS limits the current through the output drivers. The output drivers are transistors within the DIS module. The output driver is used to open and close the ground path of a coil primary circuit. The DIS module electronically limits current through a coil.

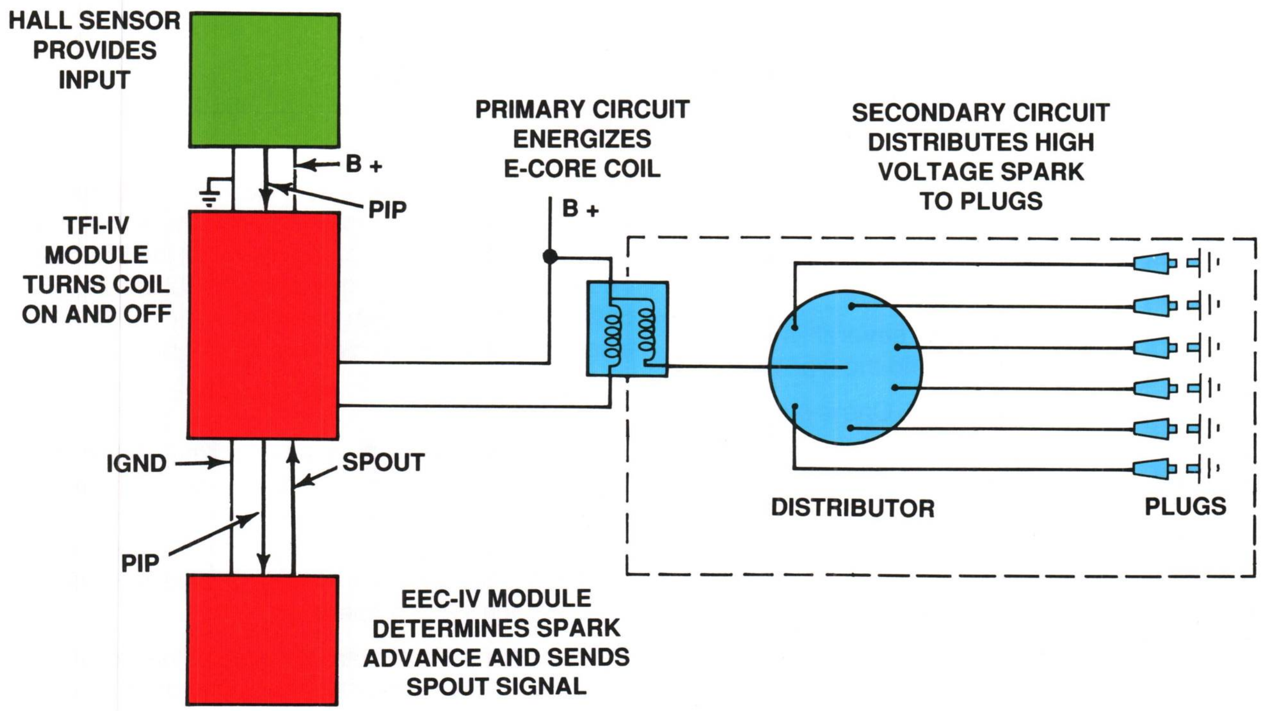
IGNITION SYSTEM OPERATION

As you already know, the purpose of the ignition system is to ignite the air/fuel mixture in each combustion chamber in the proper firing order sequence at the precise instant required for the engine speed and load conditions. Now we will provide a brief description of basic ignition system operation.

The electrical portion of any ignition system contains two separate circuits; primary and secondary. The main purpose of the primary circuit is to energize the ignition coil in order to produce the high voltage required in the secondary circuit. The secondary circuit distributes this high voltage for firing spark plugs (Figure 2-15).


PRIMARY CIRCUIT ENERGIZES IGNITION COIL PACK
B +
PLUGS
1 +
5 -
3 +
4 -
2 +
6 -
CAM SENSOR
CRANK SENSOR
SENSORS PROVIDE INPUT
DIS MODULE TURNS COILS ON AND OFF
SECONDARY CIRCUIT DISTRIBUTES HIGH VOLTAGE SPARK TO PLUGS
IDM
SPOUT
CID
PIP
EEC-IV MODULE DETERMINES SPARK ADVANCE AND SENDS SPOUT SIGNAL

DIS - DISTRIBUTORLESS IGNITION SYSTEM


HALL SENSOR PROVIDES INPUT
B +
PIP
PRIMARY CIRCUIT ENERGIZES E-CORE COIL
B +
SECONDARY CIRCUIT DISTRIBUTES HIGH VOLTAGE SPARK TO PLUGS
TFI-IV MODULE TURNS COIL ON AND OFF
IGND
SPOUT
PIP
DISTRIBUTOR
PLUGS
EEC-IV MODULE DETERMINES SPARK ADVANCE AND SENDS SPOUT SIGNAL

TFI-IV IGNITION SYSTEM

Figure 2-15. EEC-IV and Ignition Modules Control Timing and Distribute Spark

The challenge is to provide maximum spark for best torque (MBT). This means introducing the high voltage spark to the proper plug at the right time, depending on engine operating conditions. For the best engine performance, constant spark timing adjustments are required.

The EEC-IV module determines spark timing adjustments. EEC-IV uses input from engine sensors, plus information stored in calibration and look up tables. Some information is constant and does not change, while input from the sensors changes frequently.

For example, combustion of gasoline occurs at a fixed rate. The length of time for an ignition coil to reach its current limiting area is also fixed. On DIS, base timing is fixed at engine assembly and there are no provisions for initial timing adjustments.

Ignition of the air/fuel mixture is usually BTDC of the compression stroke as measured in degrees of crankshaft rotation. However, spark timing must be adjusted to introduce a spark into the proper spark plug earlier under some conditions and later under other conditions. Under load, for instance, the spark must be delivered later to prevent spark knock. At higher RPM, spark must be delivered earlier so that the combustion will have time to completely burn the air/fuel mixture at the correct time. To deliver the spark earlier, the primary coil must be energized sooner (Figure 2-16).

In today's electronically controlled engines, the EEC-IV module works with an ignition module to control timing and distribute the high voltage spark.

With the ignition switch closed, battery voltage is applied to the primary winding in the ignition coil. The EEC-IV module uses sensor input, plus information stored in the module to calculate spark advance. EEC-IV then sends a digital SPOUT signal to control timing. To energize the coil, the ignition module completes a ground path for the primary winding of the coil. A magnetic field builds up around both the primary and secondary windings of the ignition coil.

Then, based on SPOUT, the ignition module opens the ground path to the primary winding of the ignition coil. The magnetic field around the windings collapses and current is induced into the secondary winding. A high voltage spark is produced and distributed to the correct spark plug (Figure 2-15).

In addition, when the primary ground path is opened, a high back-voltage results in the primary circuit. This voltage spike is used for the IDM and tach signals.

Although the basic operation of the EEC-IV module and ignition coils is the same, there are distinct differences between ignition systems. In "OVERVIEW OF IGNITION SYSTEMS," some details of the differences between DIS and TFI-IV are explained.

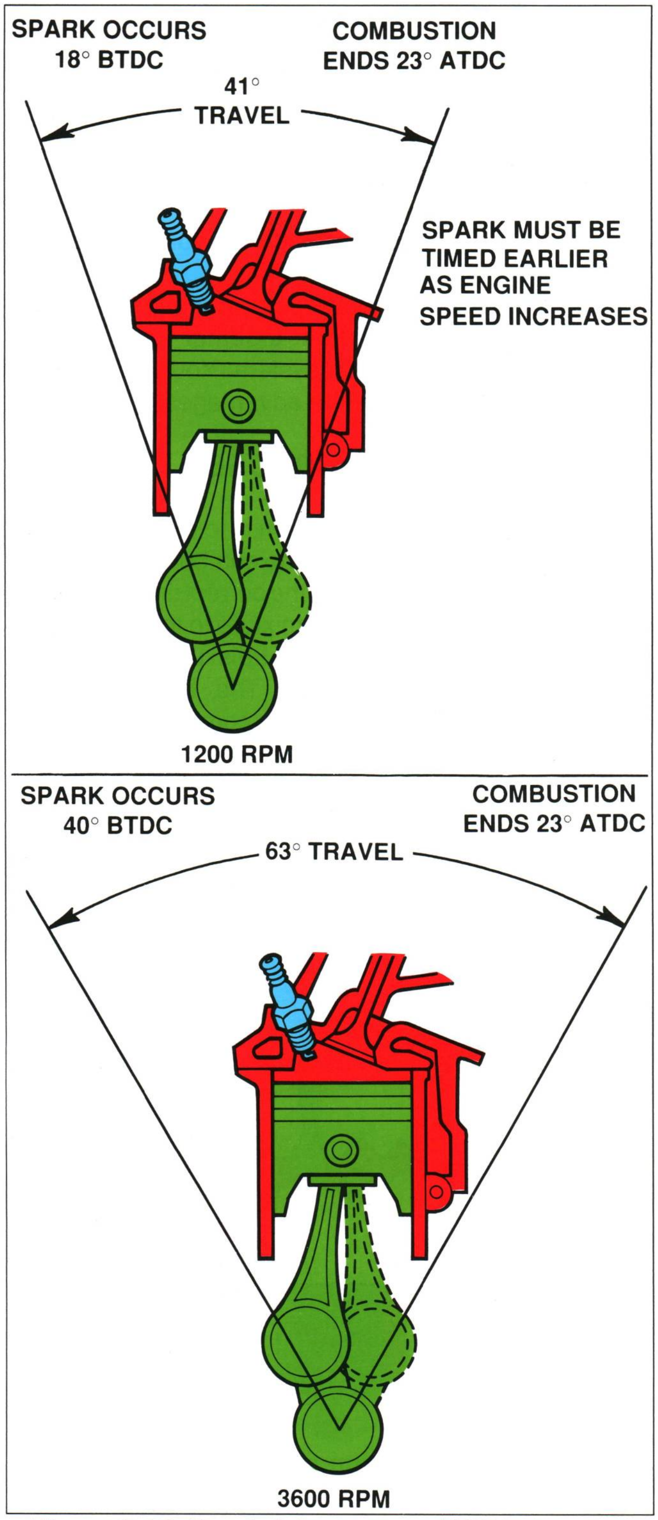


Figure 2-16. Spark Advances as RPM Increases

DESCRIPTION OF DIS

INTRODUCTION

In "OVERVIEW OF IGNITION SYSTEMS," we explained the purpose of the ignition system and the importance of its precise operation. We also mentioned the advantages of the DIS system over the TFI-IV system. In "FUNDAMENTALS OF IGNITION SYSTEMS," we covered some of the theories and fundamentals of operation common to all automotive ignition systems used to this date.

In this section, we will look at the individual components of DIS and the function of each. Once you understand the components and how they operate, it will be easy to understand how they work together to meet the requirements of the ignition system. You'll also quickly recognize and appreciate the advantages of DIS.

IGNITION SYSTEM PURPOSE

The purpose of an ignition system is to ignite the air/fuel mixture when it is delivered to the combustion chamber, in the correct sequence and at the correct time. The EEC-IV module controls the air/fuel mixture to the combustion chamber. The DIS module controls the sequence in which the cylinders are fired. The EEC-IV module determines the correct time for combustion. As you know, ignition timing is expressed in degrees before top dead center (BTDC).

Ignition timing is adjusted constantly. Many factors affect ignition timing, including: engine RPM, coolant temperature, EGR flow rate, intake air temperature and volume, throttle position, manifold absolute pressure, barometric pressure, and engine knock. The EEC-IV module monitors these conditions through various sensors.

IGNITION SYSTEM OVERVIEW

As you know, for an engine to run, the air/fuel mixture must be ignited during the compression stroke. To accomplish this combustion event, the EEC-IV module controls the fuel injectors and sends a SPOUT signal to the DIS module. As in TFI-IV systems, SPOUT tells the ignition module when to fire the coil. However, TFI-IV uses one E-core coil and a distributor to provide the high voltage spark to the plugs. The distributorless ignition system (DIS) eliminates the distributor and uses multiple coils instead (Figure 3-1). Each coil fires two spark plugs at the same time.

The spark plugs are paired so that one plug fires during the compression stroke and its companion plug fires during the exhaust stroke. The next time that coil is fired,

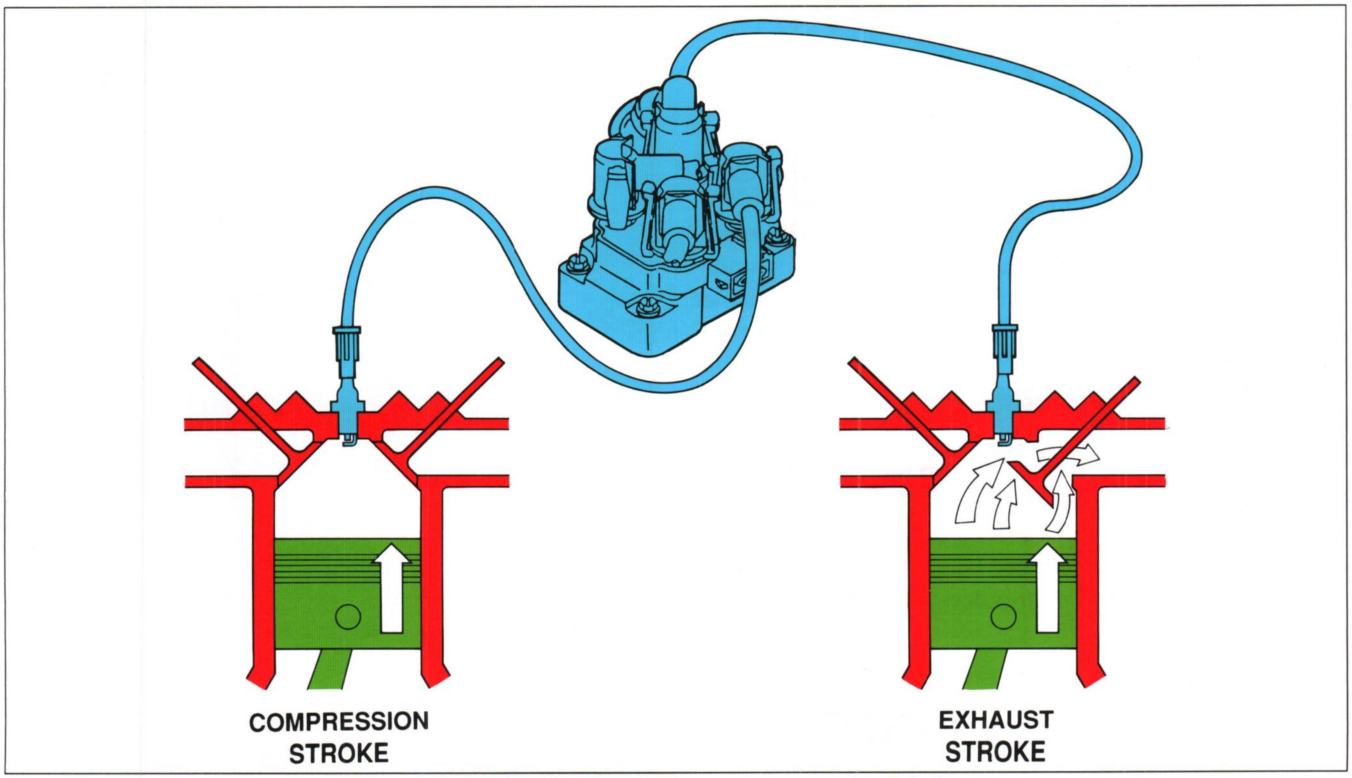


Figure 3-1. Spark Plugs Fire in Pairs - 2.3L DP Shown

the plug that was on exhaust will be on compression, and the one that was on compression will be on exhaust. The spark in the exhaust cylinder is wasted but little of the coil energy is lost.

A profile ignition pickup (PIP) signal provides base timing information. A cylinder identification (CID) signal is required so the DIS module knows which coil within a coil pack to fire. On SEFI engines, CID is used by the EEC-IV module for fuel control.

IGNITION SYSTEM COMPONENTS

The ignition system consists of: the battery, ignition switch, DIS module, EEC-IV module, spark plugs, plug wires, PIP sensor, CID sensor and ignition coils (Figure 3-2). The 3.8L SC and 3.0L SHO engines use one, six tower coil pack. The 2.3L DP engine uses two, four tower coil packs.

The ignition system is separated into two circuits: a primary, low voltage circuit and a secondary, high voltage circuit. Although the circuits are separate, they do function together and relate closely to each other.

DIS VEHICLE APPLICATION

For 1989, DIS is used on three engines:

- the six-cylinder 3.8L Supercharged (SC).
- the six-cylinder 3.0L Super High Output (SHO).
- the four-cylinder 2.3L Overhead Cam (OHC) Dual Plug (DP).

All three are multi-point fuel injected engines. The 3.8L SC and 3.0L SHO are sequential electronic fuel injection (SEFI) engines. In SEFI systems, the injectors are fired as the intake valve opens for that cylinder.

The 2.3L OHC (DP) multi-point electronic fuel injection (EFI) fires the injectors in pairs (1-4 and 2-3), once every crankshaft revolution. In addition, this four-cylinder engine uses eight spark plugs and incorporates a dual plug inhibit (DPI) feature.

Due to the different requirements of an SEFI six-cylinder engine and an EFI four-cylinder engine with dual plugs,

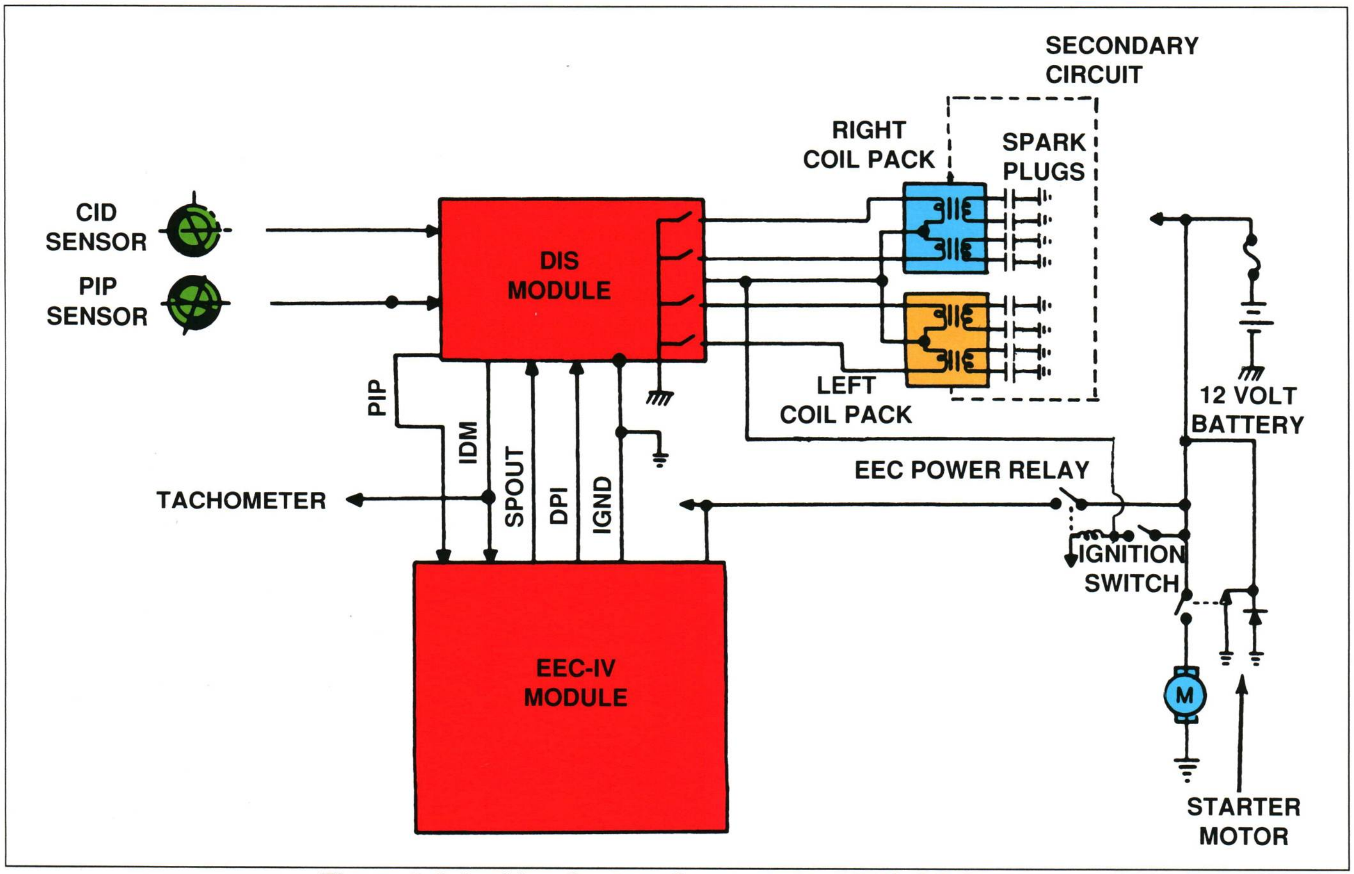


Figure 3-2. Ignition System Components - 2.3L DP Shown

there are two versions of DIS for 1989. Although the design of the two systems is basically the same, there are some distinct differences in the components used and system operation.

DIS COMPONENTS - 3.8L SC AND 3.0L SHO

We will begin by covering the ignition system components used on the 3.8L SC and 3.0L SHO engines. Then we will highlight the differences of the components on the 2.3L DP engine.

For each component we will explain its function, then describe the various parts of the component and where the component is located; finally, we will explain how these parts operate to perform the function of the component.

The EEC-IV module plays an important role in the operation of DIS. Although not just a component of DIS, we will cover the EEC-IV module as it pertains to DIS. Later on, in "DIS OPERATION," we will explain how the EEC-IV module interacts with DIS.

By now, most of you have worked with and understand the basic operation of both EEC-IV and TFI-IV systems. As we explain the DIS components and their operation, you will realize that most of the components are very similar to existing components used with the EEC-IV and TFI-IV. Think of DIS not as new technology, but as adapting and fine tuning existing technology to further improve ignition system operation.

Basically, DIS consists of three general types of components (Figures 3-3 and 3-4): sensors, controllers, and output devices. The sensors are PIP and CID; the controller is the DIS ignition module; and the output devices are the DIS coil pack and the spark plugs. We'll cover the sensors first, then the controllers, and finally the output devices.

SENSORS - 3.8L SC and 3.0L SHO

As we learned in "FUNDAMENTALS OF IGNITION SYSTEMS" and "OVERVIEW OF IGNITION SYSTEMS," some very precise information on engine operation is required by the ignition system. The DIS module needs this information to determine which coil to fire. The EEC-IV module needs this information to determine the correct air/fuel mixture and when a spark plug should be fired. Together the EEC-IV and DIS modules obtain optimum engine operation and minimize harmful emissions. The job of the sensors is to provide this information.

The 3.8L SC and 3.0L SHO ignition systems use two separate sensors:

- the profile ignition pickup (PIP) or crankshaft sensor.
- the cylinder identification (CID) or camshaft sensor.

PIP Sensor

FUNCTION

The function of the PIP or crankshaft sensor is to detect the position and speed of the engine crankshaft. The position of the crankshaft is stated in degrees of crankshaft rotation. The number is expressed in degrees before top dead center (BTDC) or after top dead center (ATDC). Engine speed, of course, is revolutions per minute (RPM). The sensor relays this information in the form of a square wave signal to be used by the EEC-IV and DIS modules.

If you are familiar with how the PIP signal is generated by the Universal distributor in the TFI-IV system, that information will serve as a good base to understand how the signal is generated in the DIS system.

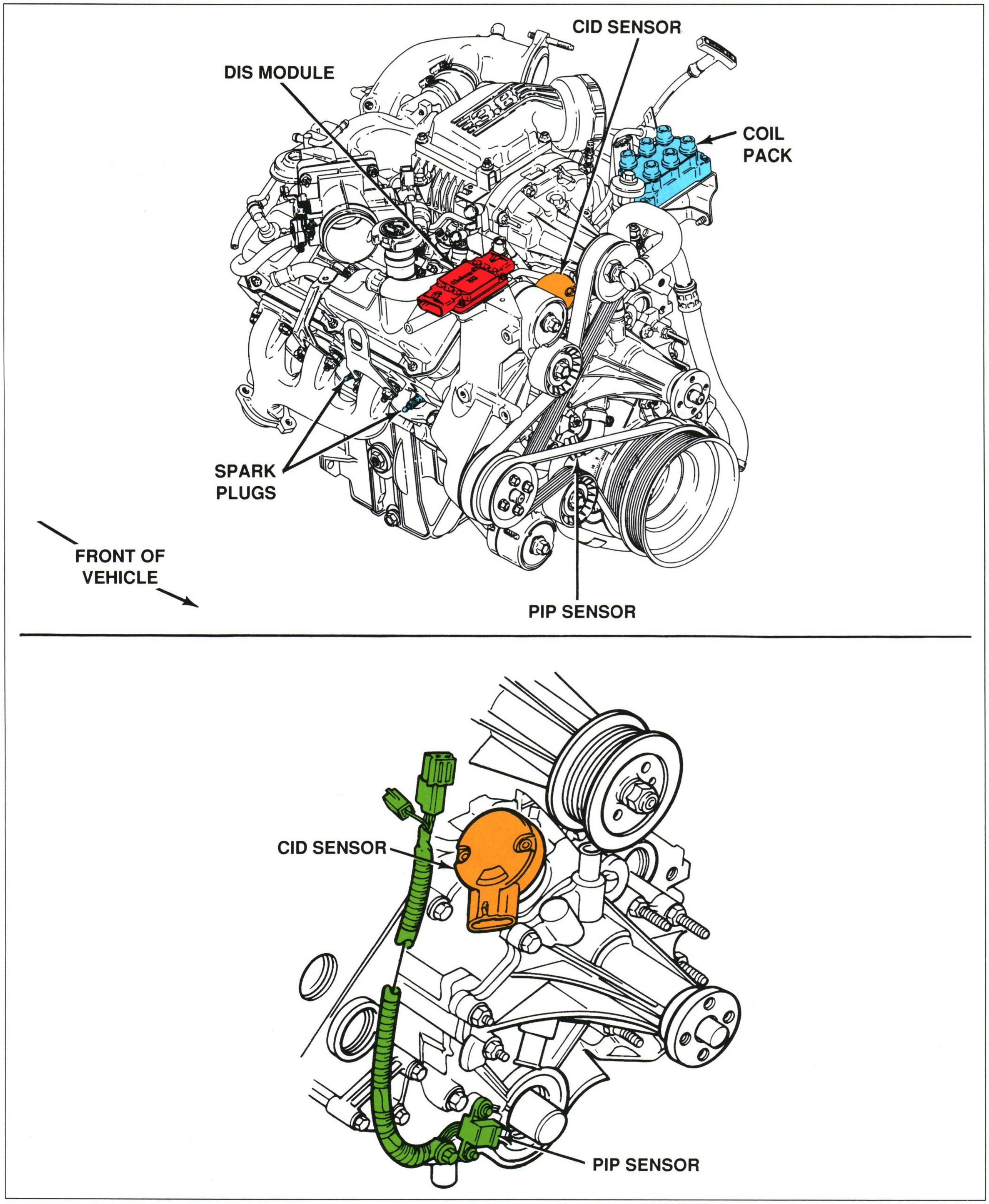


Figure 3-3. DIS Components - 3.8L SC

DESCRIPTION OF DIS

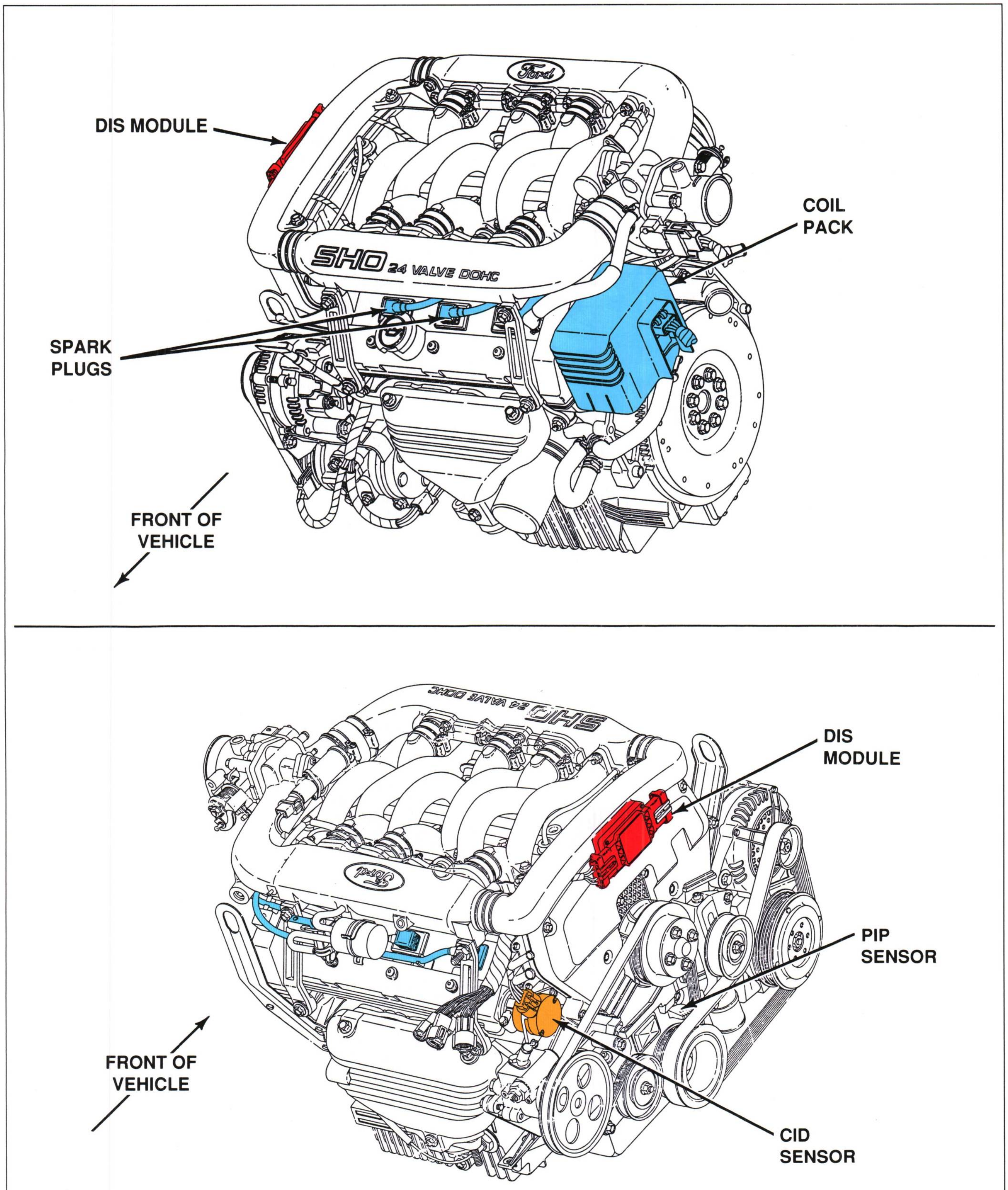


Figure 3-4. DIS Components - 3.0L SHO

COMPONENTS

The PIP sensor (Figure 3-5) is a digital output, single Hall device. This single Hall sensor includes:

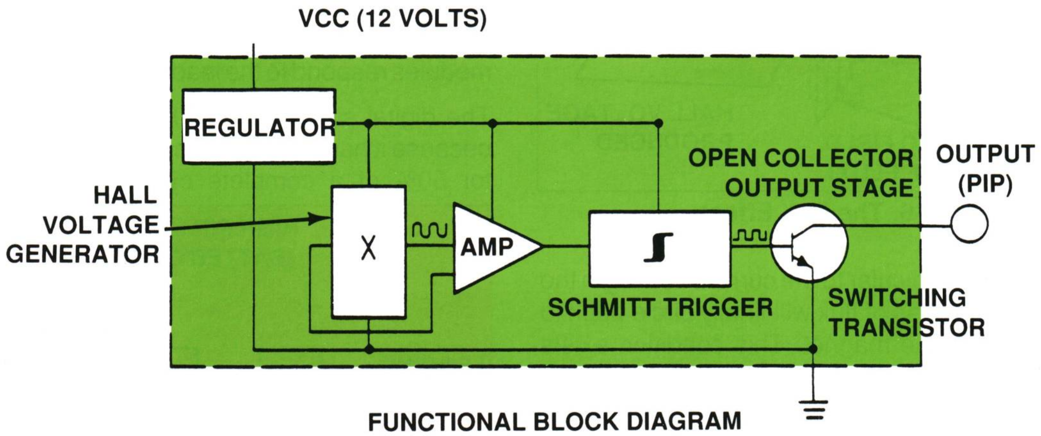
- a stationary Hall effect device with an integrated circuit.
- a stationary permanent magnet.
- a rotary vane cup.

The PIP sensor is mounted to the engine block near the crankshaft pulley and hub assembly. The rotating vane cup is part of the crankshaft pulley and hub assembly.

OPERATION

Operation of the PIP sensor is based upon the Hall effect (Figure 3-6). The Hall effect is a process in which current is passed in one direction through a slice of semiconductor material. By passing a magnetic field through this same semiconductor, a small voltage change is produced in the output device.

A permanent magnet is placed parallel to and directly across from the Hall effect device. The Hall effect device and the permanent magnet (Figure 3-7) are separated by an air gap. Magnetic lines of flux will pass through the air gap. Then, the lines of flux will cut through the



FUNCTIONAL BLOCK DIAGRAM OF HALL EFFECT DEVICE

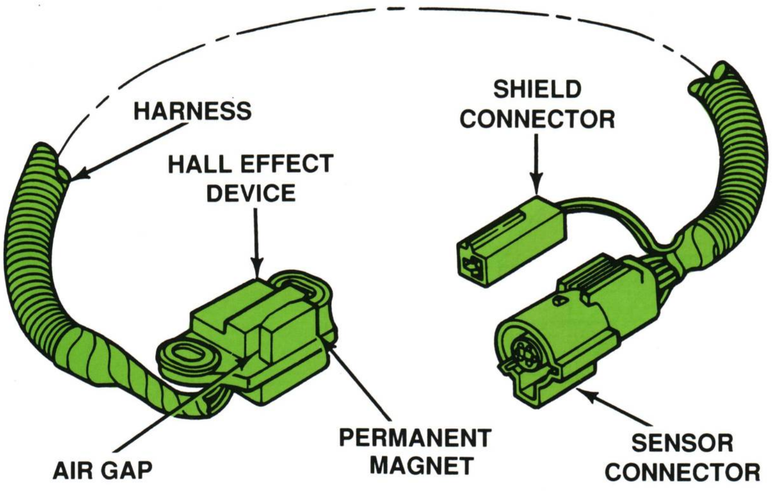


Figure 3-5. PIP Sensor - 3.8L SC and 3.0L SHO

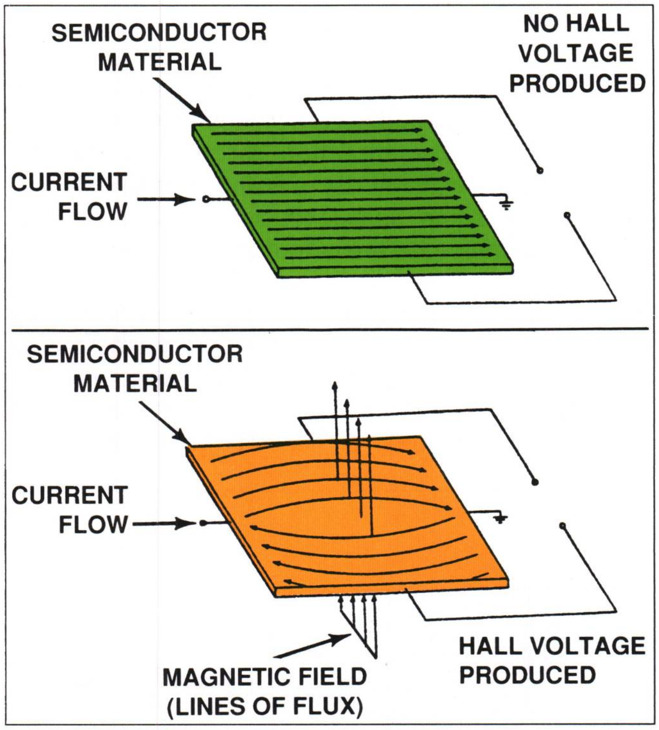


Figure 3-6. The Hall Effect

semiconductor perpendicular to the current flowing in the semiconductor. The lines of flux will finally circle back to the opposite pole of the magnet. This condition exists when the window of the rotary vane cup is between the magnet and the Hall device.

As the vane passes through the opening, the flux lines are shunted by the vane back to the magnet. This prevents flux lines from passing through the Hall effect device and the integrated circuit in the Hall device output is low. This results in a PIP signal that is high (battery voltage).

When the vane clears the opening, the window edge causes a low PIP signal to be produced. A low signal is from zero to 0.4 volts. The output of the PIP sensor is a digital signal.

A digital signal has a leading edge and trailing edge. One edge is positive going and the other negative going. For the examples in this book, the positive going edge results in a high voltage or ON signal. The negative going edge results in a low voltage or OFF signal. The leading edge of the PIP signal is positive, which means the signal is ON and the voltage is high. The trailing edge of the PIP signal is negative, which means the signal is OFF and the voltage is low (Figure 3-8).

The DIS module and the EEC-IV module look for the transition or change in a digital signal. That is, the modules respond to the leading edges and trailing edges.

The digital signal of the PIP sensor is a square wave because it has a 50% duty cycle. That is, the signal is ON for 50% of a complete cycle and then OFF for the

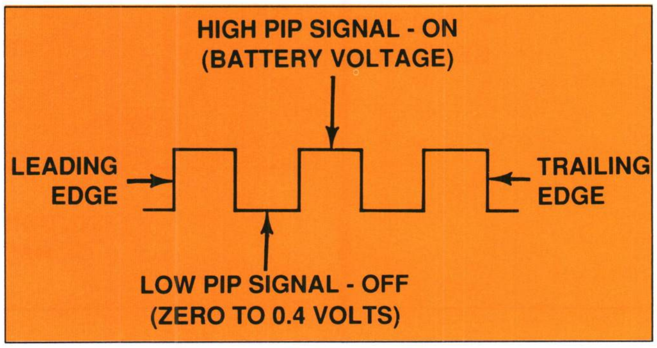


Figure 3-8. Digital Signal

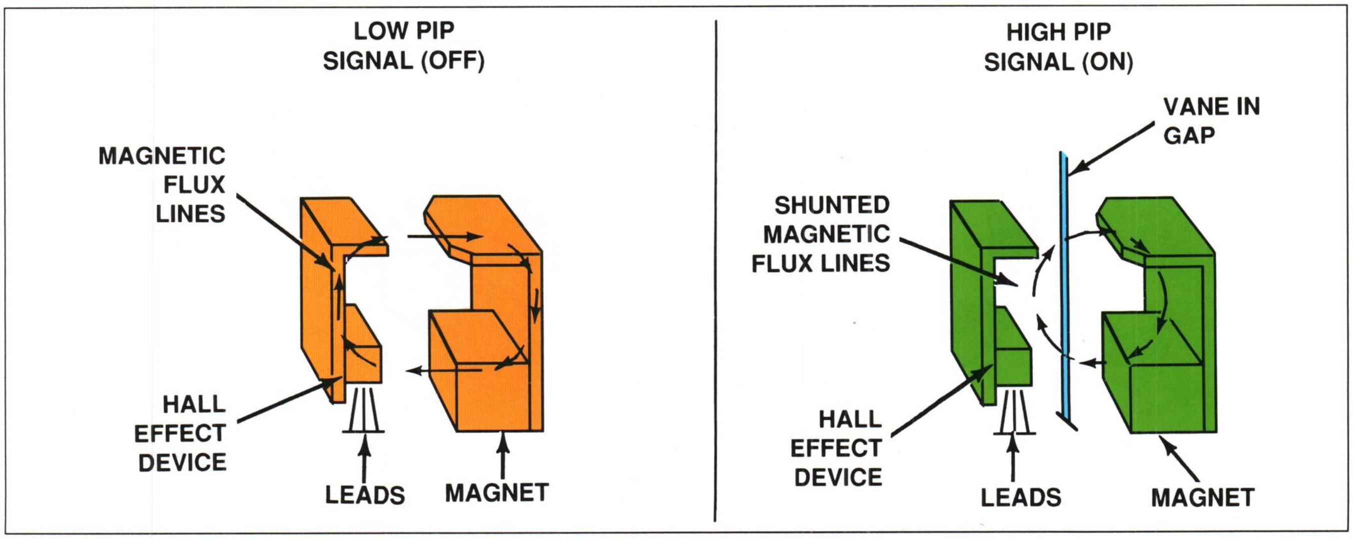


Figure 3-7. PIP Sensor Operation

remaining 50% of a complete cycle. For example, during one crankshaft revolution PIP is ON for 60°, OFF for 60°, ON for 60°, OFF for 60°, ON for 60°, and OFF for the final sixty degrees.

The crankshaft cup used as the rotating vane cup has three teeth or vanes. Therefore, the PIP sensor used for the 3.8L SC and 3.0L SHO produces three PIP signals per crankshaft revolution (Figure 3-9). A window of the vane cup is in the gap between the magnet and the Hall device for 60° of crankshaft revolution. This means the signal is zero volts or OFF. Then, for the next 60°, the vane is in the gap, the magnetic flux lines are shunted, and a high PIP signal is generated.

Just after a vane enters the air gap, the output of the PIP sensor changes state to a high voltage. The vanes on the crankshaft rotary vane cup are positioned so that a high voltage signal, or leading edge, occurs when a piston is 10° BTDC (Figure 3-10). This reflects base timing on six-cylinder DIS engines and is not adjustable. For example, a leading edge of PIP occurs 10° before pistons 1 and 5 reach TDC. When the crankshaft rotates 120°, a second leading edge of PIP will occur 10° before pistons 3 and 4 reach TDC. When the crankshaft rotates another 120°, the third leading edge of PIP occurs 10° before pistons 2 and 6 reach TDC.

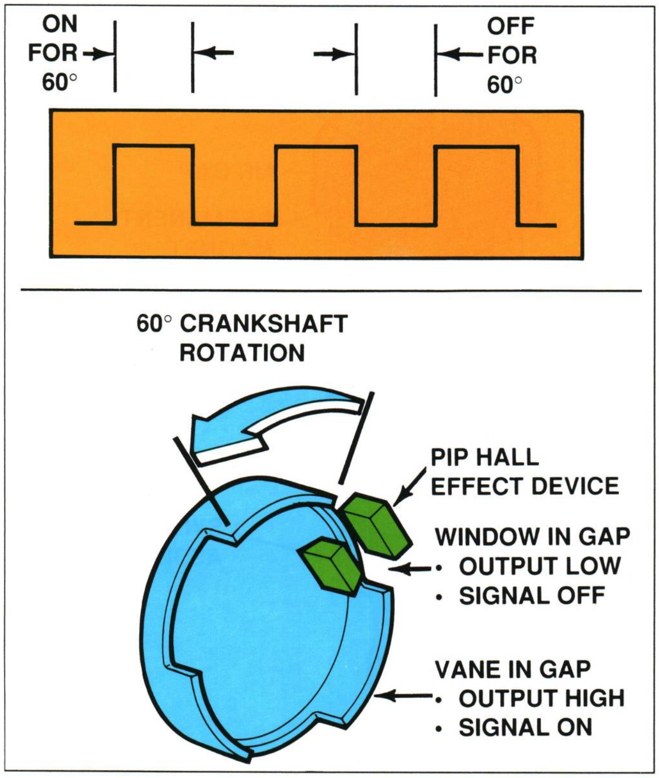


Figure 3-9. PIP Signal 3.8L SC and 3.0L SHO

REMEMBER THE FOLLOWING:

- the PIP sensor is a Hall effect type sensor that produces a digital output, square wave signal.
- PIP sends a high signal (battery voltage) when a vane shunts the magnetic lines of flux.
- PIP sends a low signal (zero to 0.4 volts) when a window allows flux lines to cut through the Hall device.
- the 3.8L SC and 3.0L SHO DIS PIP sensor produces three high PIP signals for each crankshaft revolution.
- PIP has a 50% duty cycle.
- a leading edge of PIP always occurs at 10° BTDC of a piston. Base timing is 10° BTDC of piston 1.

CID - Cylinder Identification Sensor

FUNCTION

The function of the CID sensor is to detect the position of the engine camshaft. Camshaft position is used to

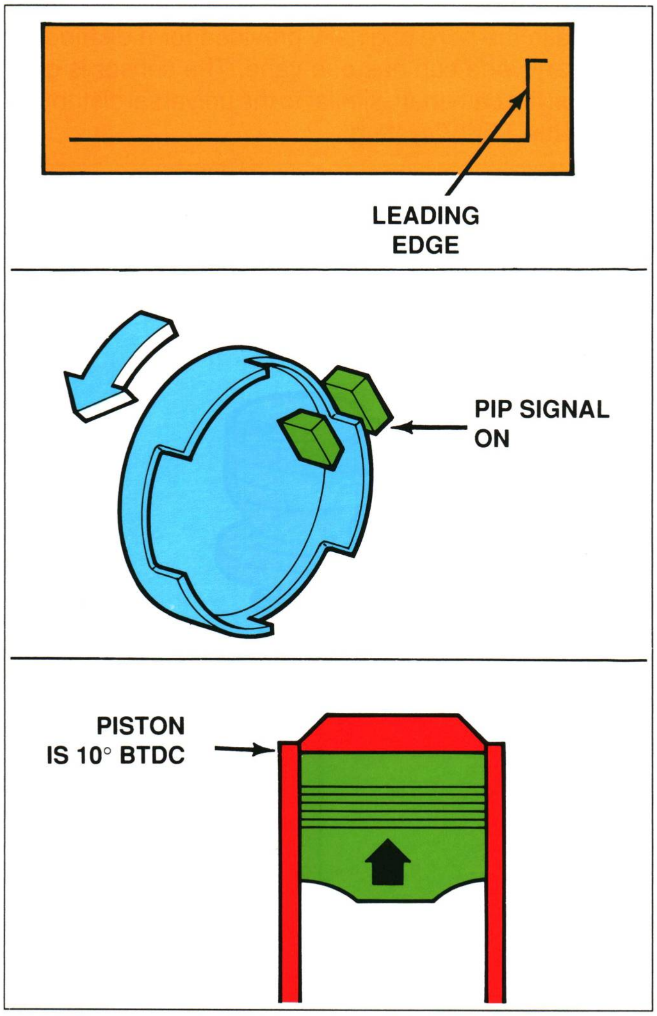


Figure 3-10. PIP Leading Edge 10° BTDC - 3.8L SC and 3.0L SHO

identify when piston 1 is 26° ATDC of its compression stroke. This reference information is used by the DIS module and the EEC-IV module. The DIS module uses the CID signal to select the proper coil to fire.

The 3.8L SC and 3.0L SHO are sequential electronic fuel injected (SEFI) engines and the EEC-IV module uses the CID signal for fuel control. On these engines the CID sensor is cam driven so that piston 1 compression stroke could be identified. This identification is needed for accurate sequential firing of the fuel injectors.

COMPONENTS

Like the PIP sensor, the CID sensor is also a digital output, single Hall device. The 3.8L SC and 3.0L SHO use the same sensor which includes the Hall device, the integrated circuit and the permanent magnet. However, the mounting adapter, mounting location, and what serves as the rotating vane cup differ.

The 3.8L SC CID sensor (Figure 3-11) is designed to be installed in the bore originally provided for a distributor. The rotary vane cup has one vane. The sensor is gear driven off the camshaft, similar to the universal distributor used in the TFI-IV system.

The 3.0L SHO CID sensor (Figure 3-12) is located on the right end of the rear cylinder head close to cylinder 1. The rotary vane cup also has one vane or tooth. The vane cup is attached to and driven directly by the camshaft.

OPERATION

By using a Hall effect device, the CID sensor generates a CID signal in the same manner as the PIP sensor. The output of the CID sensor is also a digital square wave signal. A high CID signal is battery voltage. A low CID signal is zero to 0.4 volts.

The difference between the PIP sensor and the CID sensor is that the rotary cup for the CID sensor has only one vane and is driven by the camshaft and not the crankshaft. As the camshaft rotates, the vane is between the Hall effect device and the magnet for 180° of camshaft rotation. The magnetic lines of flux are shunted and the CID signal is ON. A window is between the Hall effect device and the magnet for the remaining 180° of camshaft rotation. The magnetic lines of flux cut through the Hall effect device and the CID signal is OFF (Figure 3-13).

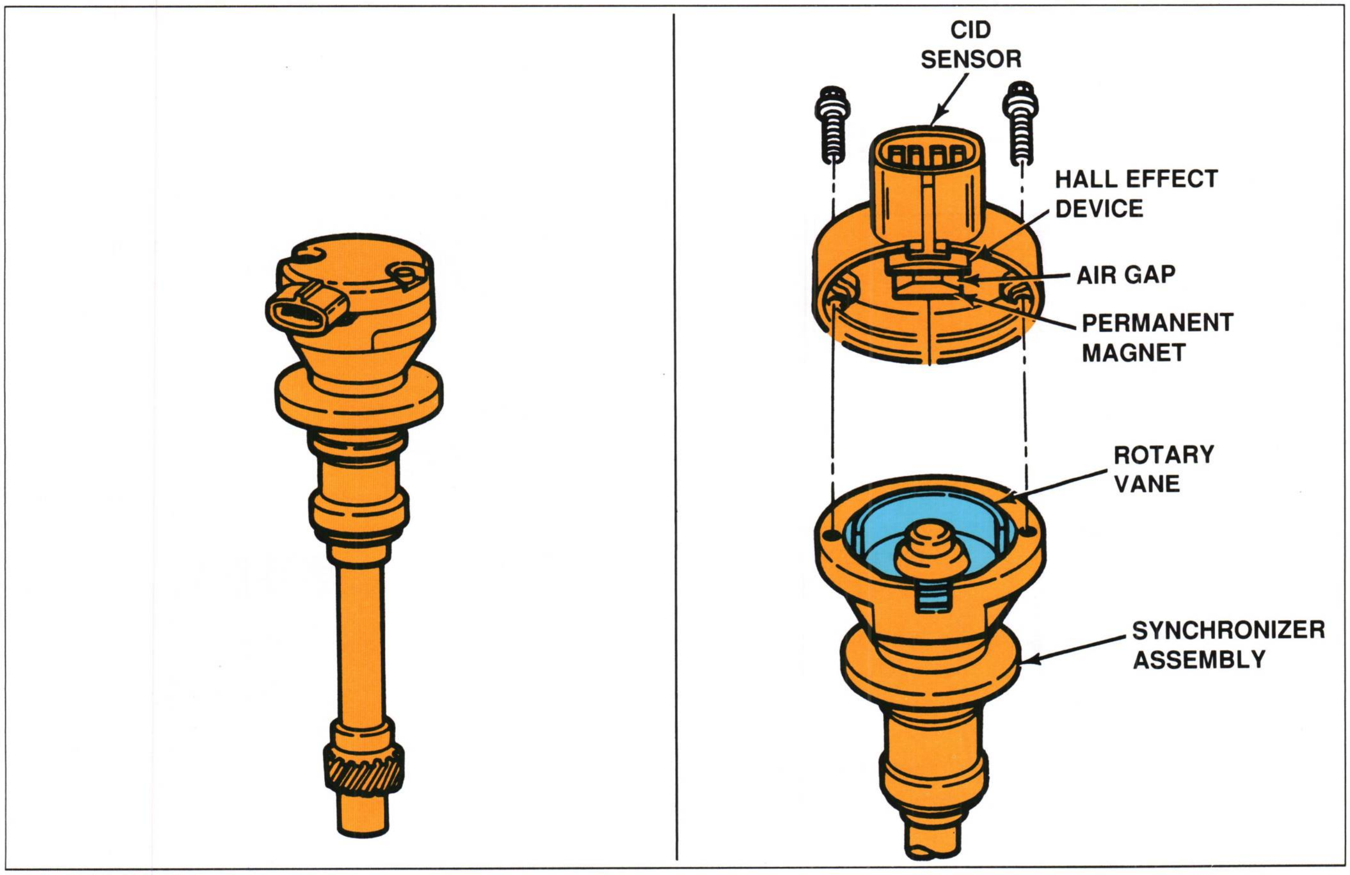


Figure 3-11. CID Sensor and Synchronizer - 3.8L SC

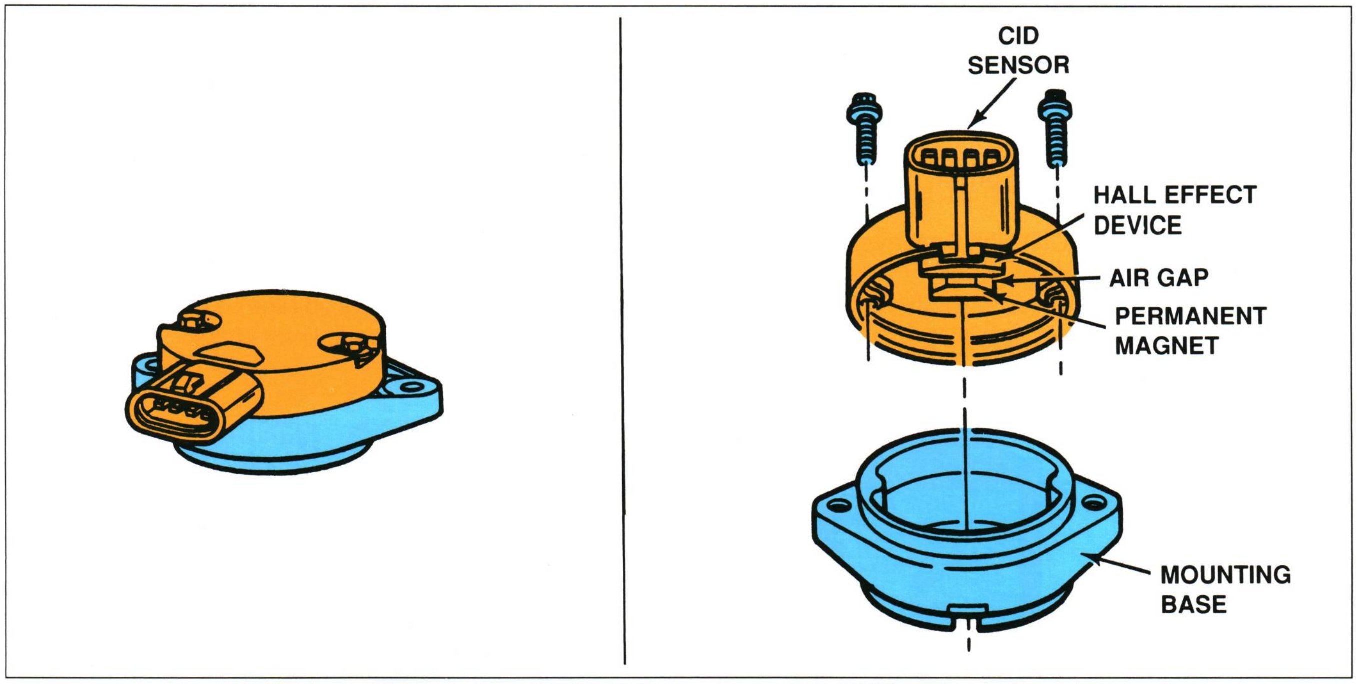


Figure 3-12. CID Sensor - 3.0L SHO

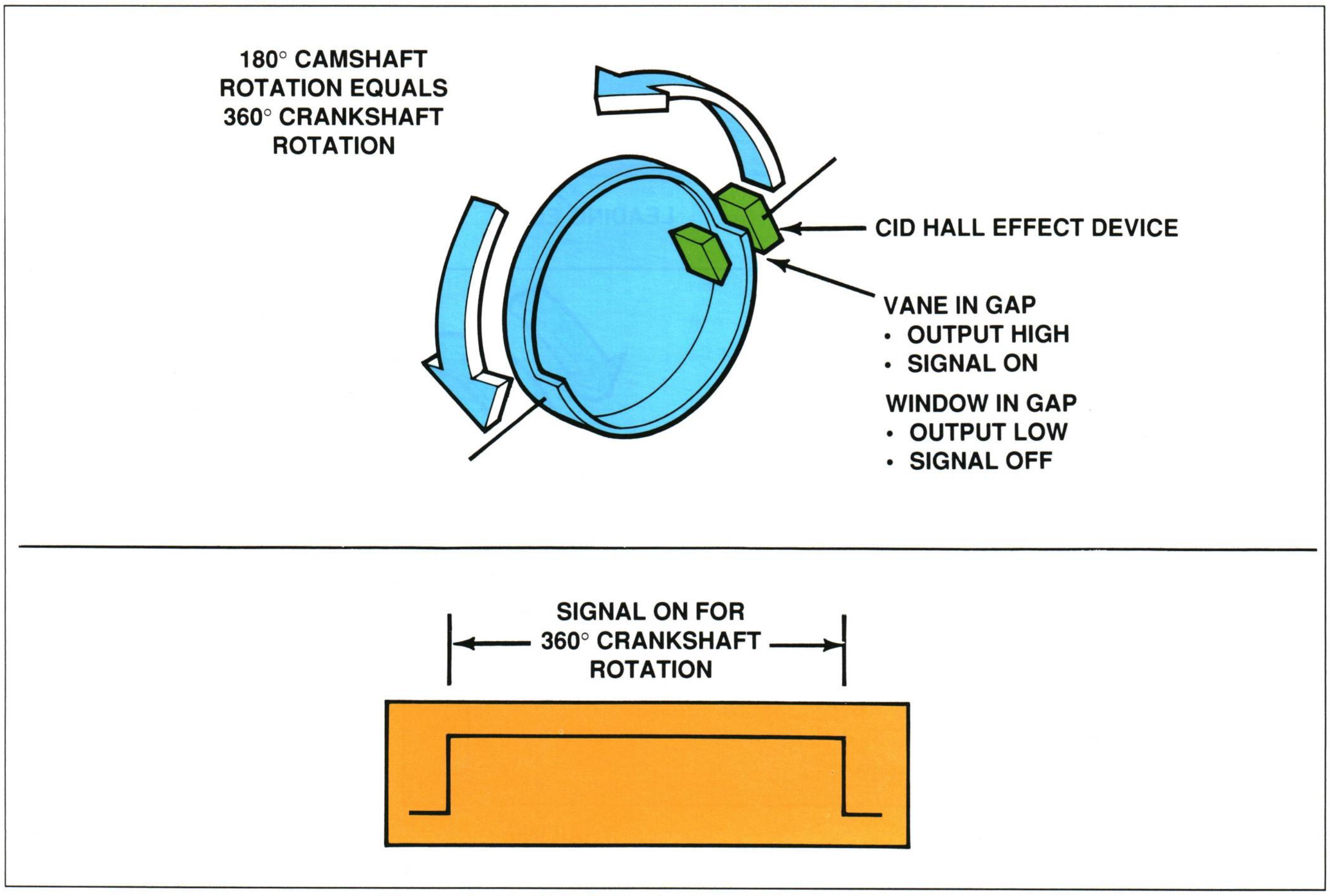


Figure 3-13. CID Signal - 3.8L SC and 3.0L SHO

Like the PIP sensor, the CID sensor has a 50% duty cycle. The signal is ON for half a camshaft revolution and OFF for half a camshaft revolution. The crankshaft rotates at twice the speed of the camshaft. For every two rotations of the crankshaft, the CID sensor generates one leading edge and one trailing edge.

The leading edge of the CID signal always occurs at 26° ATDC of the power stroke of piston 1. The trailing edge of CID always occurs 26° ATDC of the intake stroke of piston 1 (Figure 3-14). At 26° ATDC, the CID signal occurs outside the spark timing window during a "quiet" time. In this way, the DIS and EEC-IV modules can't confuse CID with other signals. The CID signal is not adjustable.

REMEMBER THE FOLLOWING:

- the CID sensor is a Hall effect type sensor that produces a digital output, square wave signal.
- a high CID signal (battery voltage) is produced when a vane shunts the magnetic lines of flux.

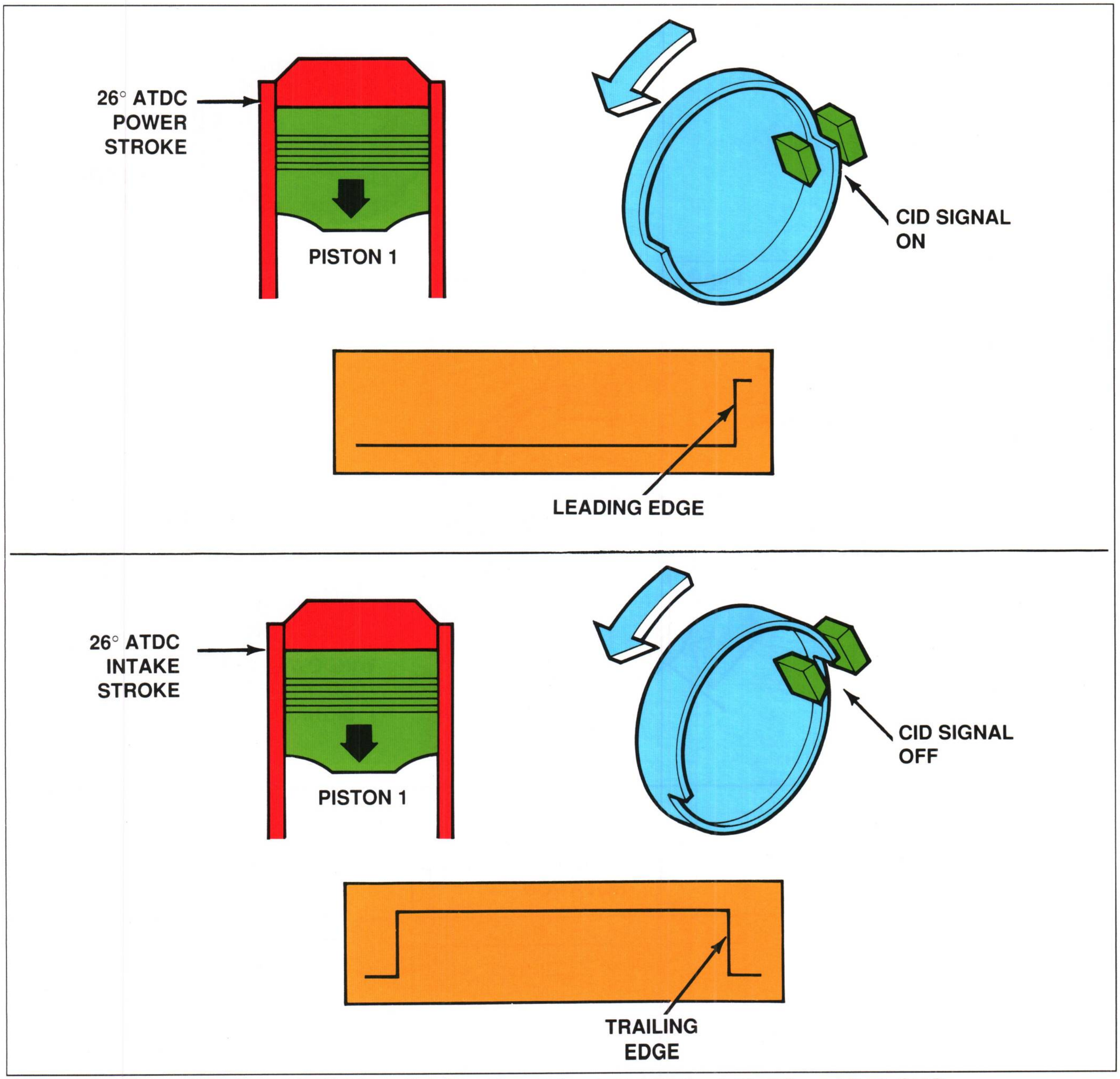


Figure 3-14. CID Leading/Trailing Edge 26° ATDC - 3.8L SC and 3.0L SHO

- a low CID signal (zero to 0.4 volts) is produced when a window allows flux lines to cut through the Hall device.
- the 3.8L SC and 3.0L SHO DIS CID sensor produces one high CID signal each camshaft revolution, which equals one high CID signal every two crankshaft revolutions.
- CID has a 50% duty cycle.
- the leading edge of CID occurs when piston 1 is 26° ATDC of its power stroke.
- the trailing edge of CID occurs when piston 1 is 26° ATDC of its intake stroke.

CONTROLLERS - 3.8L SC AND 3.0L SHO

The information obtained by the sensors is used by two modules to control DIS:

- the DIS ignition module.
- the EEC-IV module.

DIS Ignition Module

FUNCTION

The 3.8L SC and 3.0L SHO DIS ignition modules (Figure 3-15) perform the following six important functions:

- provide ground for the ignition system through two of the DIS module mounting screws. This is not a vehicle ground.
- select which coil within the coil pack to fire.
- contain solid-state electronic switches which control current to the coil primary circuits within each coil pack.
- limit current flow in each coil primary circuit to a maximum of 5.5 amps (± 0.5 amps).
- generate the ignition diagnostic monitor (IDM) signal, which provides diagnostic information about the ignition system to the EEC-IV module.
- provide failure mode effects management (FMEM) operation.

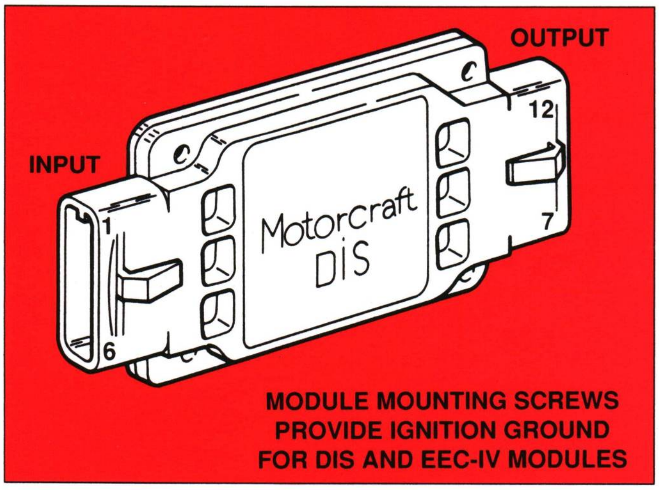

OUTPUT
INPUT
12
1
7
6
Motorcraft
DIS
MODULE MOUNTING SCREWS PROVIDE IGNITION GROUND FOR DIS AND EEC-IV MODULES

Figure 3-15. DIS Ignition Module

COMPONENTS

The DIS ignition module is a thick film integrated design. The module contains a ceramic substrate thick film assembly and three output drivers mounted on a metal base plate and potted in a plastic housing. The 3.0L SHO and 3.8L SC six-cylinder engines use a DIS coil pack that contains three coils. The DIS module uses one output driver for each coil. The module includes two, six-pin connectors to attach the DIS wiring harness. Four mounting screws secure the module to the engine. Two of the screws provide ignition ground for the module and the ignition system.

On the 3.0L SHO engine, the DIS module is mounted on the upper right end of the engine (Figure 3-4). On the 3.8L SC engine, the DIS module is mounted to a bracket slightly above and forward of the front edge of the right valve cover (Figure 3-3).

OPERATION

The 3.8L SC and 3.0L SHO DIS modules receive the following four inputs through one of the six-pin connectors of the DIS wiring harness:

- pin number one provides battery voltage to the module.
- pin number two provides for CID sensor input.
- pin number three is not used.
- pin number four provides for PIP sensor input.
- pin number five provides spark timing (SPOUT) input from the EEC-IV module.
- pin number six is not used.

The DIS module provides the following five outputs through the second, six-pin connector to the wiring harness:

- pin number seven provides ignition ground (IGND).
- pin number eight provides the ground path for the primary circuit of coil 1.
- pin number nine provides the ground path for the primary circuit of coil 3.

- pin number ten is not used.
- pin number eleven provides the ground path for the primary circuit of coil 2.
- pin number twelve provides IDM output for the EEC-IV module and tachometer operation.

The DIS module operates in the following manner to perform the six functions of the module.

IGNITION GROUND (IGND)

The module provides ignition ground through pin number seven. Through internal wiring, pin seven is connected to two of the four mounting screws of the module. The two mounting holes have solid brass inserts to provide a solid contact to ground. The metal base plate of the module is then mounted to the engine to complete the ground path.

NOTE - Failure to properly install the mounting screws of the DIS module will result in improper ground for the DIS and EEC-IV modules. Without proper ground the DIS and EEC-IV modules will not operate and the engine will not start.

Remember, this is a low current ground for the ignition system. This is not a source for vehicle ground.

CHOOSING A COIL

The DIS module uses the CID signal (pin number two) to determine which coil to fire and the SPOUT signal (pin number five) during start-up to know when to fire a coil.

Keep the following in mind:

- the leading edge of a PIP signal occurs when any piston is 10° BTDC.
- the leading edge of a CID signal occurs when piston 1 is 26° ATDC of its power stroke.
- the trailing edge of CID occurs when piston 1 is 26° ATDC of its intake stroke.

At engine cranking, the DIS module looks for a transition or change in the CID signal, from low to high or high to low. When the DIS module sees a leading or tailing edge of CID, the module prepares to fire coil 2 of the coil pack. After the CID transition occurs, the module looks for a trailing edge of SPOUT to turn coil 2 ON. Then the next leading edge of SPOUT is used by the DIS module to turn OFF the primary current to coil 2, which in turn fires coil 2 (Figure 3-16). If the SPOUT circuit opens, the DIS module will use the PIP signal to fire the coils.

The DIS module always fires the coils within a coil pack in sequence. At engine start-up, coil 2 always fires first, followed by coil 3, then coil 1, then coil 2 and so on. In this way, firing the coils is synchronized with compression. Since the coils continue to fire in the same order, they remain synchronized while the engine is running, even if the CID signal to the DIS module is lost. While the engine is running, SPOUT tells the DIS module when to fire the next coil.

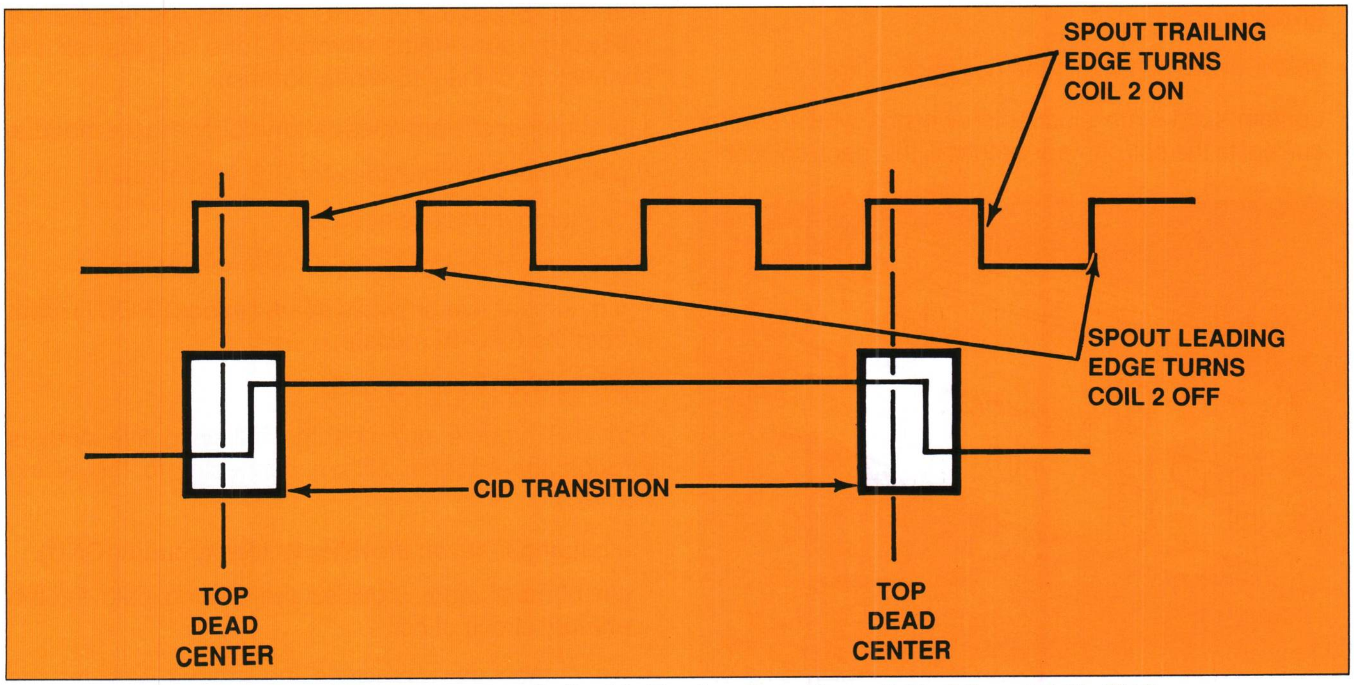

SPOUT TRAILING EDGE TURNS COIL 2 ON
SPOUT LEADING EDGE TURNS COIL 2 OFF
CID TRANSITION
TOP DEAD CENTER
TOP DEAD CENTER

Figure 3-16. Choosing the Coil with Engine Cranking - 3.8L SC and 3.0L SHO

FIRING THE COIL

Through pin number five, the DIS module receives a SPOUT signal from the EEC-IV module. This SPOUT signal is applied to the switching amplifier in the DIS module. As you already know, the TFI-IV ignition module also uses a SPOUT signal from the EEC-IV module when the engine is running.

The DIS module uses SPOUT to control current flow in the coil primary circuits. SPOUT is a digital signal similar to the PIP and CID signals. However, SPOUT has a variable duty cycle.

Remember, the DIS module uses CID to determine which coil to turn ON. PIP or SPOUT determines when the coil is to be turned ON and OFF.

The DIS module turns ON a coil primary current when it sees a trailing edge of SPOUT (Figure 3-17). To turn a coil primary current ON, the DIS module closes the coil primary circuit via the output driver for that coil.

To fire the charged coil, the DIS module opens, that is, interrupts current flow in the primary circuit of the charged coil. The DIS module uses the next leading edge of SPOUT to signal an output driver which fires the coil.

The output driver is a solid-state device which provides an abrupt open in the coil primary circuit. When we explain the operation of the ignition coil, you'll understand the importance of this abrupt interruption.

The output driver can be thought of as a toggle switch to ground. The leading edge of SPOUT opens the switch to stop current flow in the coil primary circuit. The trailing edge of SPOUT tells DIS to close the switch and current flows in the coil primary circuit.

LIMITING COIL PRIMARY CURRENT TO 5.5 AMPS (± 0.5 AMPS)

It is the job of the DIS module to limit current current flow in the coil primary to 5.5 amps (± 0.5 amps).

The DIS module uses a current sensing resistor to limit current in the coil primary circuit. The current sensing resistor measures voltage drop across the terminals of the resistor. Based on the voltage reference signal from the current sensing resistor, the DIS module maintains 5.5 amps (± 0.5 amps) to the coil.

GENERATING IDM

IDM is a digital signal (Figure 3-17) generated by the DIS module then sent to the EEC-IV module. Remember, the SPOUT signal from the EEC-IV module tells DIS when to turn a coil ON and OFF. IDM then tells the EEC-IV module if a coil did turn ON and OFF. You can think of the SPOUT signal as a shout by the EEC-IV module, and IDM as the echo coming back to the EEC-IV module.

The IDM signal is generated by the DIS module and SPOUT. A coil fires when the coil primary current is interrupted. This abrupt interruption causes a high voltage kickback, approximately 380 volts, in the primary circuit. A high voltage detector within the DIS module looks for this voltage spike which only occurs if the coil fired. A leading edge of SPOUT fires the coil and almost immediately the voltage spike is detected by the DIS module. The module generates the leading edge of the IDM signal. The trailing edge of SPOUT causes the trailing edge of IDM. If a coil does not fire, IDM remains low or OFF.

The leading edge of SPOUT (beginning of a high signal) fires a coil. The trailing edge (beginning of a low signal) starts current flow in the primary circuit of the next coil to fire. Therefore, when all the coils fire as instructed by the SPOUT signal, the IDM signal to the EEC-IV module matches the SPOUT signal.

PROVIDING FMEM

Although FMEM is a function of the DIS module, we will not explain it here in component operation. Since the DIS module only performs these functions if there is a problem in the system, we will explain how the DIS performs these functions in "DIS OPERATION."

EEC-IV Module - 3.8L SC and 3.0L SHO

The EEC-IV module is not just a component of DIS, but does interact with DIS to control the ignition system. EEC-IV monitors sensors in order to provide electronic engine control. Microprocessors within the EEC-IV module include reference information in look up tables, calibration tables and engine operating strategies. EEC-IV uses this reference information and sensor input to determine proper spark timing in an effort to achieve maximum spark for best torque (MBT).

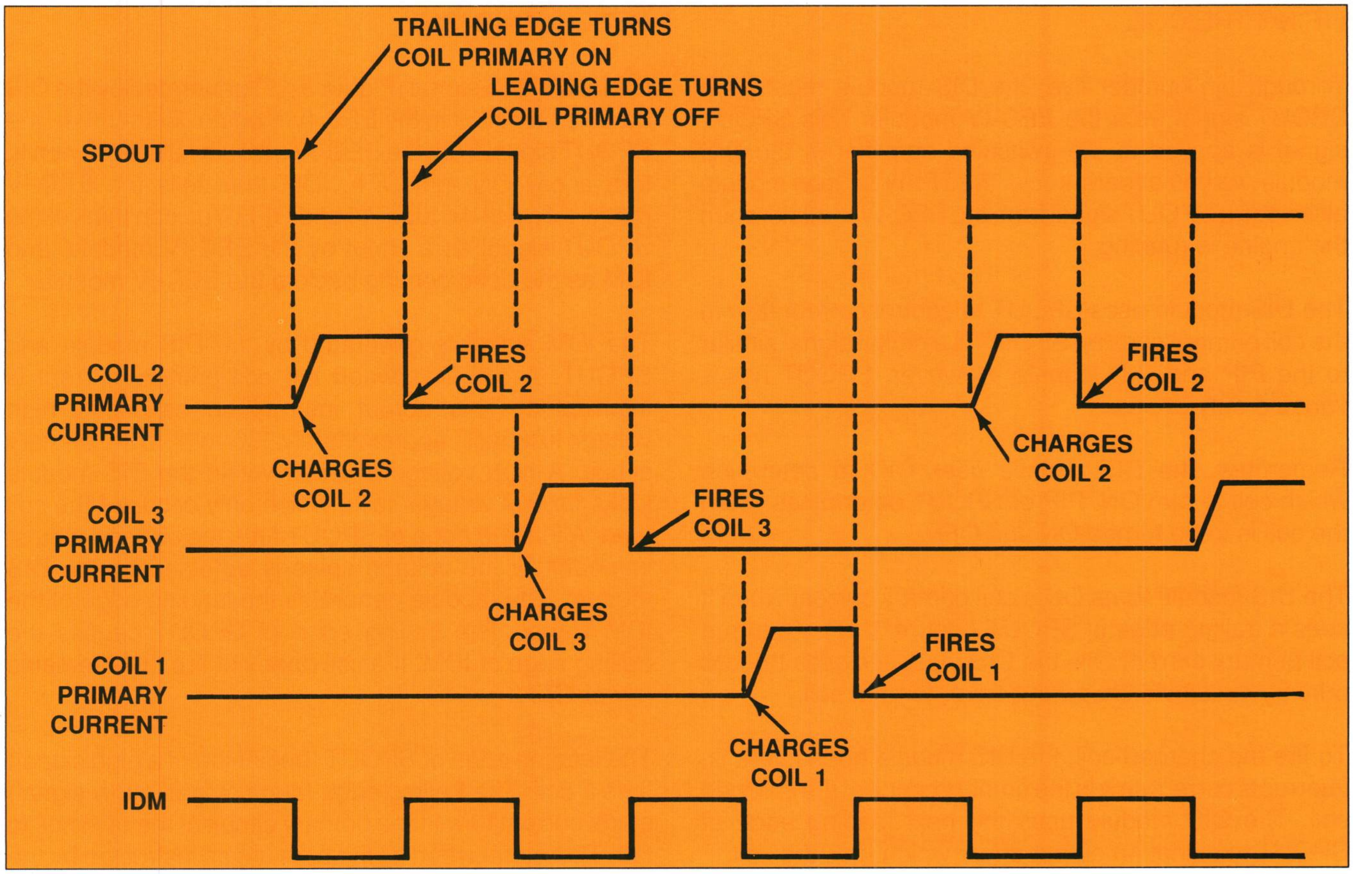


Figure 3-17. Firing Coils with Engine Running - 3.8L SC and 3.0L SHO

As far as the ignition system is concerned, the primary function of the EEC-IV module is to adjust SPOUT to advance or retard timing and thus provide the best engine operation.

EEC-IV performs many functions, but the following pertain to 3.8L SC and 3.0L SHO DIS:

- uses the PIP signal directly from the PIP sensor to monitor engine RPM and establish a crank position reference.
- uses the CID signal directly from the CID sensor to synchronize the fuel injectors on SEFI engines.
- relies on the DIS module for a low voltage, reference ground (IGND).
- through a feature known as computer controlled dwell (CCD), SPOUT determines spark angle and dwell.
- monitors IDM, which provides diagnostic information about the ignition system and is used for Self-Test.

OUTPUT DEVICES - 3.8L SC AND 3.0L SHO

DIS Coil

FUNCTION

The basic function of the DIS coil is no different than ignition coils in previous Ford ignition systems. The DIS coil provides the high voltage needed to jump the gap of the spark plugs and ignite the air/fuel mixture.

In distributor ignition systems, a single coil provides this high voltage current to the distributor cap. The distributor delivers the high voltage current to the correct spark plug. The DIS system, however, uses a coil pack which contains multiple coils. Each coil provides high voltage for two spark plugs. The coil delivers that high voltage current directly to a pair of plugs.

COMPONENTS

Since the 3.8L SC and the 3.0L SHO are six-cylinder engines, three coils are required. Each coil has two high voltage towers. Each tower supplies one plug. All three coils are mounted together in a single coil pack (Figure 3-18), which is serviced as a unit. The three coils are protected from magnetic interference so the operation of one coil does not affect the other two coils in the coil pack. A four-pin connector on the coil pack connects to the DIS wiring harness.

Each coil within a coil pack contains a primary and secondary circuit. The winding in the primary circuit is wound on a bobbin that has a silicon steel core. The winding of the secondary circuit is on a segmented bobbin. The secondary winding uses a smaller gauge wire and more turns than the primary coil. There are approximately 280 turns in the secondary winding for each turn in the primary winding. This means the ratio of turns in the primary coil compared to the secondary coil is 1-to-280.

The three primary circuits use the same ground path through the DIS module.

On the 3.0L SHO engine, the coil pack is located on the left end of the engine below and slightly forward of the throttle body (Figure 3-4). On the 3.8L SC engine, the coil pack is on the left front side of the engine slightly above and forward of the left valve cover (Figure 3-3).

OPERATION

The DIS coils receive the following inputs through its harness connector:

3.8L SC Coil Pack

- pin number one (coil 2 primary) is the ground path to pin number eleven of the DIS module.
- pin number two (coil 3 primary) is the ground path to pin number nine of the DIS module.
- pin number three (coil 1 primary) is the ground path to pin number eight of the DIS module.

3.0L SHO Coil Pack

- pin number one (coil 1 primary) is the ground path to pin number eight of the DIS module.
- pin number two (coil 3 primary) is the ground path to pin number nine of the DIS module.
- pin number three (coil 2 primary) is the ground path to pin number eleven of the DIS module.

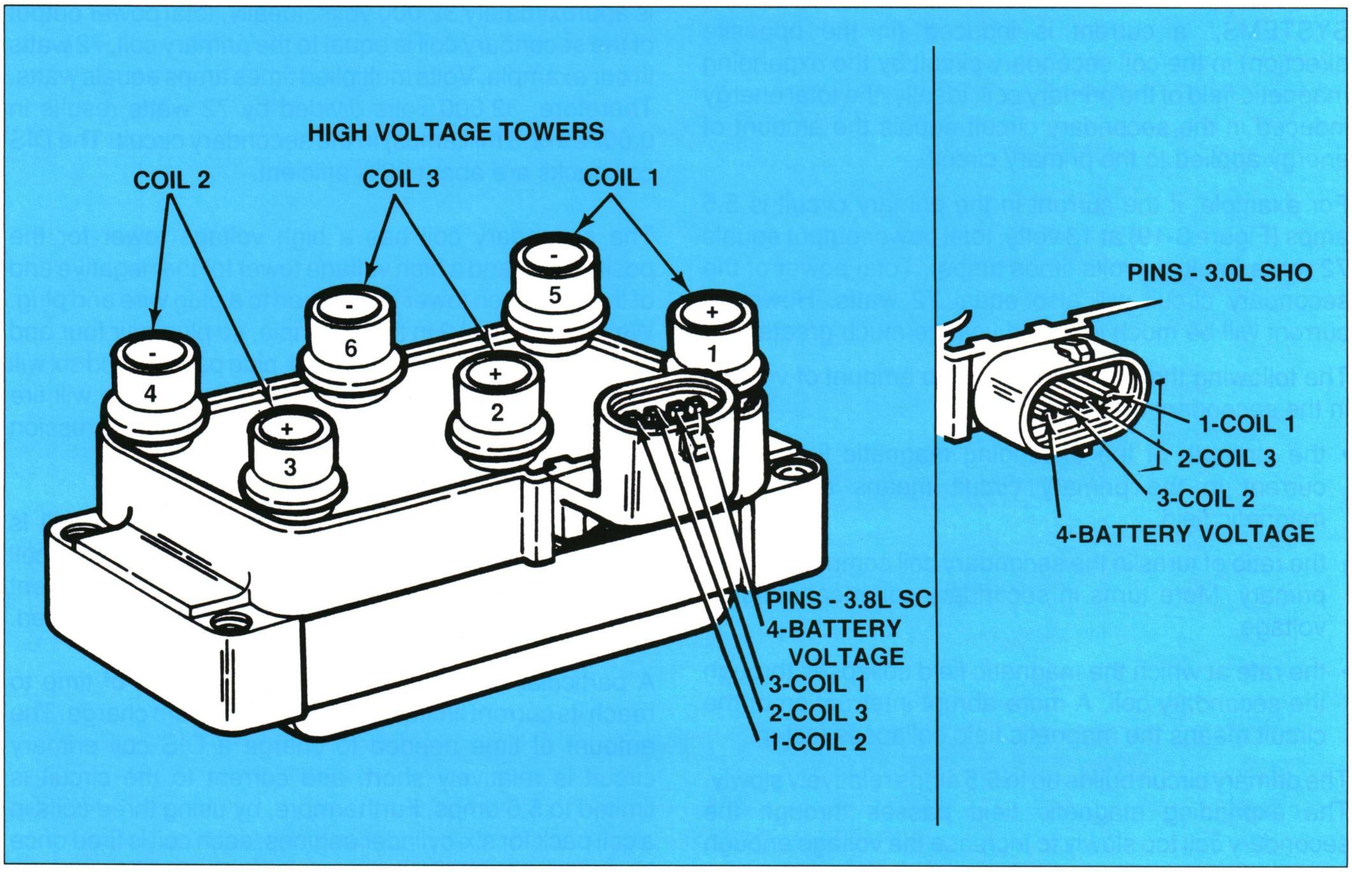


Figure 3-18. DIS Coil Pack - 3.8L SC and 3.0L SHO

The fourth pin of the connector provides battery voltage for all three coil primary circuits.

As an example of coil operation, let's say that coil 3 should be energized. DIS signals the output driver for coil 3. The output driver completes the ground path and current flows through the primary winding in coil 3. As explained in the operation of the DIS ignition module, current is limited to 5.5 amps (± 0.5 amp).

Due to the nature of magnetic fields, current, and induction, a certain amount of time is required for the coil to reach 5.5 amps. That is to say, in all ignition coils, the expanding magnetic field impedes or delays current flow in the coil primary circuit. This impedance is inductive reactance. In addition, the air and materials within the coil pack tend to delay the rate at which the magnetic field expands. This is inductive reluctance. Inductive reactance and inductive reluctance are explained in "FUNDAMENTALS OF IGNITION SYSTEMS."

A given coil will always require the same amount of time to reach maximum charge or current limitation point. This time is very short, approximately three milliseconds for DIS coils.

As we explained in "FUNDAMENTALS OF IGNITION SYSTEMS," a current is induced (in the opposite direction) in the coil secondary circuit by the expanding magnetic field of the primary coil. Ideally, the total energy induced in the secondary circuit equals the amount of energy applied to the primary circuit.

For example, if the current in the primary circuit is 5.5 amps (Figure 3-19) at 13 volts, total power output equals 72 watts (multiply volts times amps). Total power of the secondary circuit will also equal 72 watts. However, current will be much less and voltage much greater.

The following three factors affect the amount of voltage in the secondary circuit:

- the strength of the expanding magnetic field. More current in the primary circuit means a stronger magnetic field.
- the ratio of turns in the secondary coil compared to the primary. More turns in secondary coil means higher voltage.
- the rate at which the magnetic field collapses through the secondary coil. A more abrupt interruption of the circuit means the magnetic field collapses faster.

The primary circuit builds up to 5.5 amps relatively slowly. The expanding magnetic field passes through the secondary coil too slowly to increase the voltage enough to jump the spark plug gap.

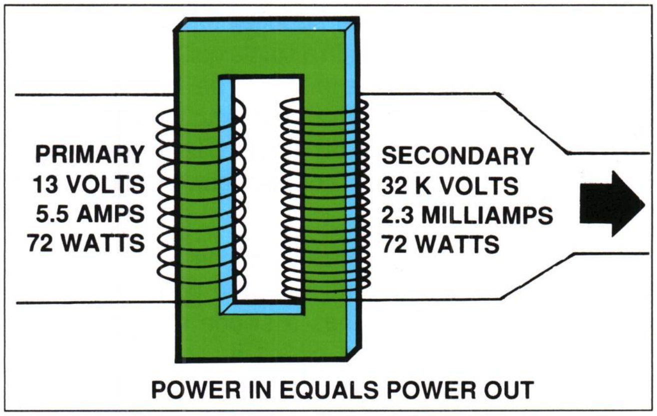


Figure 3-19. Coil Energy

Remember, the solid-state output driver in the DIS module causes an abrupt open in the primary circuit. This abrupt interruption collapses the magnetic field of the primary coil instantly. The magnetic field collapses through the secondary coil rapidly. This generates the high voltage needed to jump the plug gap.

Due to the design of the coil and how quickly the magnetic field collapses, minimum voltage in the secondary circuit is approximately 32,000 volts. Ideally, total power output of the secondary coil is equal to the primary coil, 72 watts in our example. Volts multiplied times amps equals watts. Therefore, 32,000 volts divided by 72 watts results in 0.00225 (2.3 milliamps) in the secondary circuit. The DIS coil packs are about 98% efficient.

The secondary coil has a high voltage tower for the positive end and a high voltage tower for the negative end of the coil. Each tower is attached to a plug wire and plug. We are firing coil 2 in this example, so plug pair four and three will fire. When coil 3 is fired, plug pair two and six will fire. When coil 1 is fired, plug pair one and five will fire (Figure 3-20). One piston will be on its compression stroke and the companion piston on exhaust.

Dwell is the total time the primary circuit of a coil is energized. Dwell includes the time needed for the coil primary circuit to reach maximum charge, or current limitation point, plus the time until current is interrupted.

A particular coil requires a specific amount of time to reach its current limitation point or maximum charge. The amount of time needed to charge a DIS coil primary circuit is relatively short, and current to the circuit is limited to 5.5 amps. Furthermore, by using three coils in a coil pack for six-cylinder engines, each coil is fired once for each revolution of the crankshaft. On TFI-IV systems,

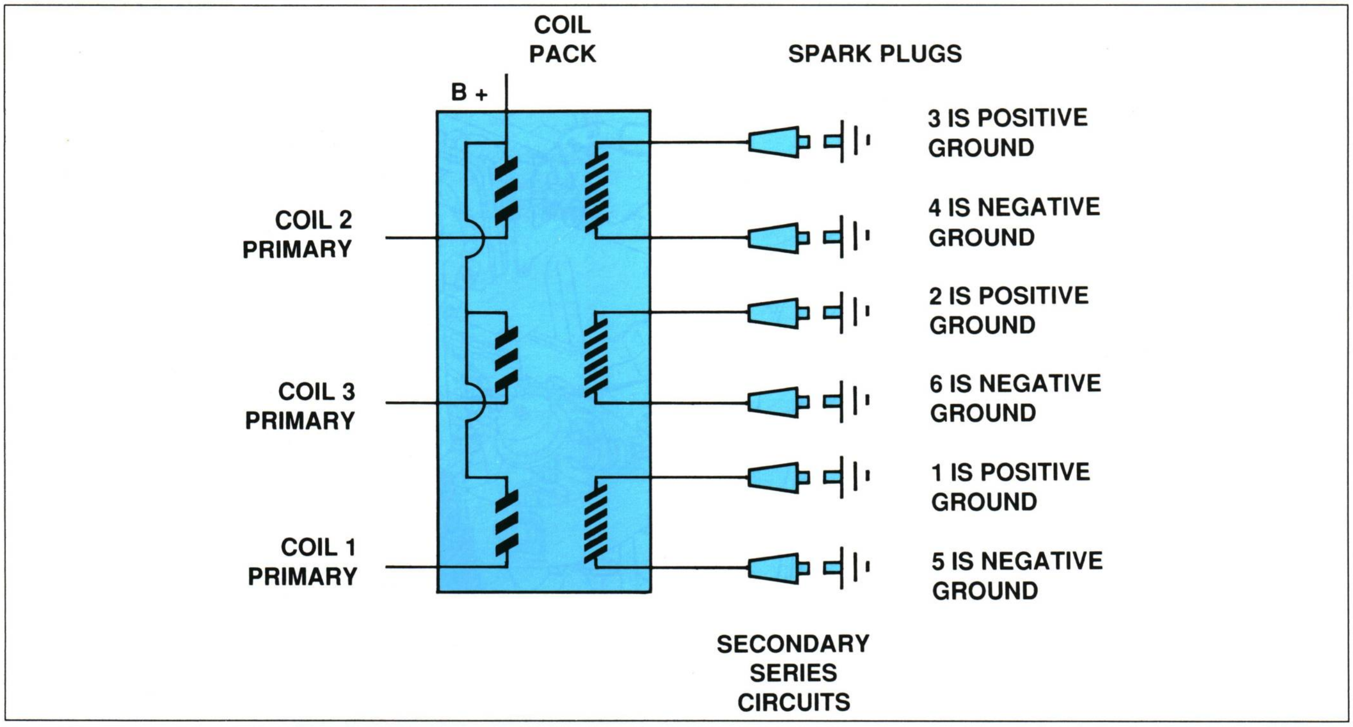


Figure 3-20. Spark Plug Circuits - 3.8L SC and 3.0L SHO

the E-core coil is fired three times for each crankshaft revolution. As you can see, these factors improve dwell, reduce stress on the coils, and increase the total allowable degrees for spark advance and retard.

DIS SPARK PLUGS - 3.8L SC AND 3.0L SHO

FUNCTION

As in previous Ford ignition systems, the function of the spark plug is still to ignite the air/fuel mixture in the cylinder.

COMPONENTS

The six-cylinder DIS uses one plug for each cylinder. 3.8L SC and 3.0L SHO engines use platinum spark plugs.

OPERATION

The difference between spark plugs in existing Ford ignition systems and DIS is in how the plugs operate. Two plugs are wired in series (Figure 3-20) with one coil. This means that one plug fires from the center electrode to the side electrode, as in existing ignition systems. The companion plug, however, fires from the side electrode to the center electrode.

One piston is on compression and its companion piston on exhaust. The plug for an individual cylinder always fires in the same direction; that is, center to side electrode or side to center electrode. When that piston is on its exhaust stroke, however, the spark is wasted. Very little coil energy is wasted because the resistance is greater in the cylinder on exhaust. Most of the available voltage jumps the gap of the plug in the cylinder on compression since the resistance is low.

DIS COMPONENTS - 2.3L DP

Now that you are familiar with DIS components, we will cover the differences in components used by the 2.3L DP DIS (Figure 3-21). The 2.3L DP DIS also uses sensors, controllers and output devices.

SENSORS - 2.3L DP

The 2.3L DP DIS uses a dual Hall sensor. The dual Hall sensor (Figure 3-22) contains the PIP sensor and the CID sensor.

DESCRIPTION OF DIS

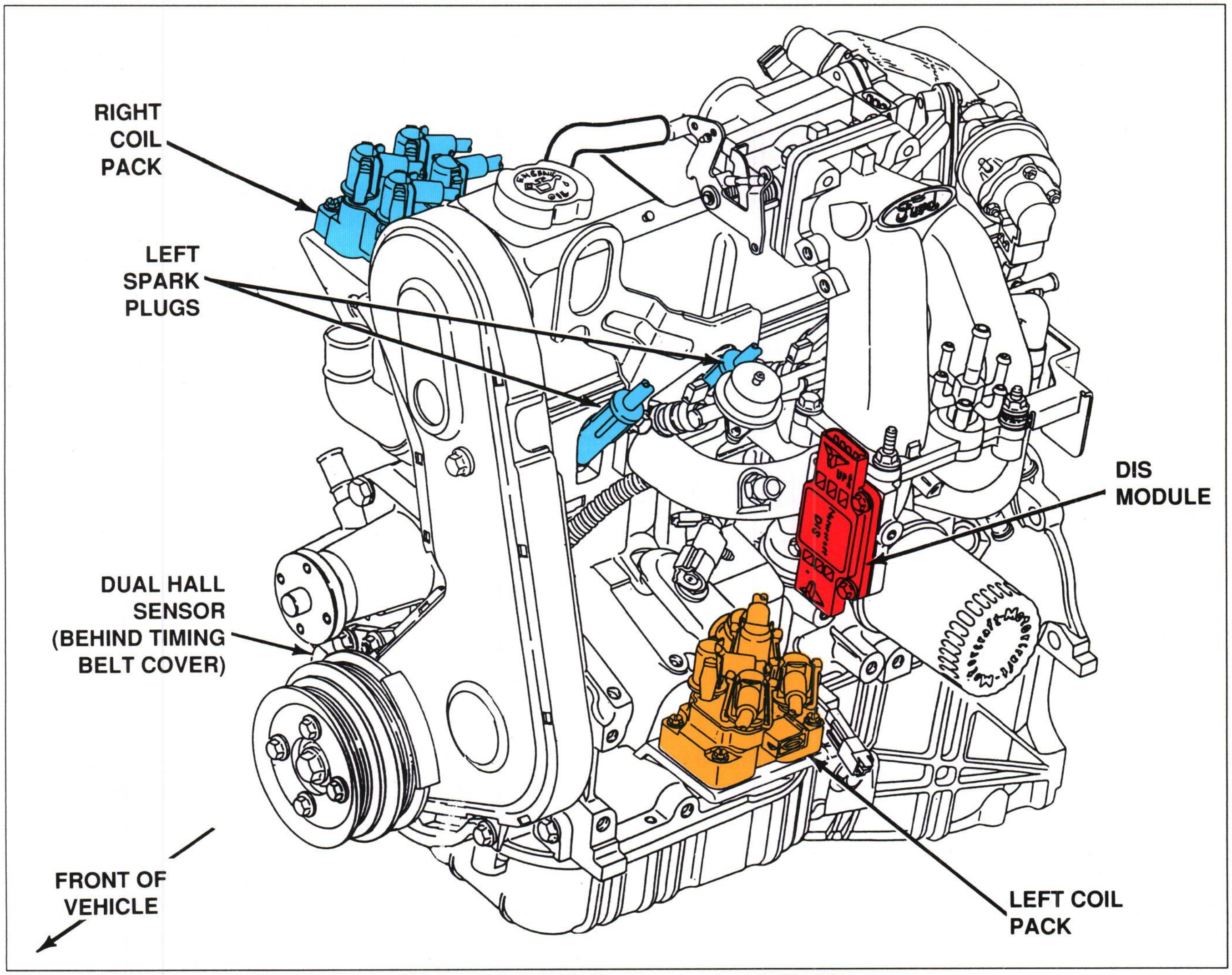


Figure 3-21. DIS Components - 2.3L DP

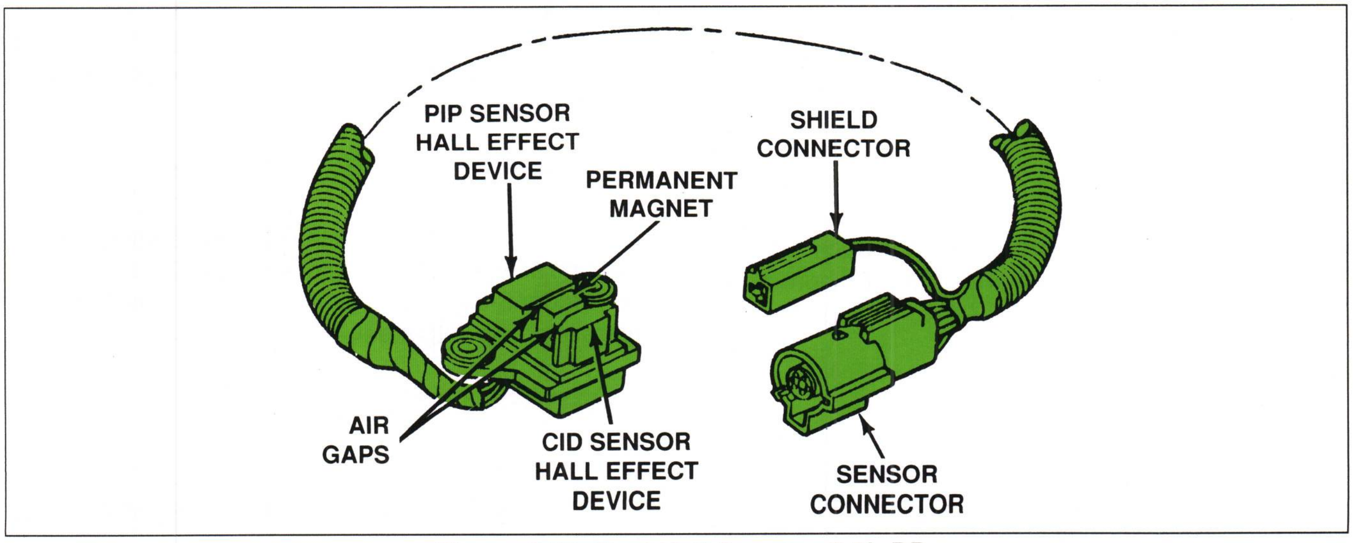


Figure 3-22. Dual Hall Sensor - 2.3L DP

Dual Hall Sensor

FUNCTION

The dual Hall sensor includes both the PIP and CID sensors in one package. Like the 3.8L SC and 3.0L SHO, the PIP signal determines crankshaft speed and position, while the CID signal identifies when piston 1 is 10° ATDC.

COMPONENTS

The dual Hall sensor includes:

- two Hall effect devices with an integrated circuit.
- one permanent magnet.
- A rotating cup that incorporates two vane cups as part of the crankshaft pulley hub assembly.

OPERATION

The Hall effect devices operate the same as the Hall effect devices used in the 3.8L SC and 3.0L SHO PIP and CID sensors. The main difference is that the dual Hall effect sensor shares one permanent magnet.

The dual Hall sensor is mounted so that the PIP cup on the crankshaft damper rotates around the outside edge of the magnet. The CID cup rotates around the inside edge of the magnet.

The PIP Hall effect device is mounted outside the path of the PIP cup allowing the cup to pass between the inside edge of the Hall effect device and the outside edge of the magnet. The CID Hall effect device is mounted inside the path of the CID cup, allowing the cup to pass between the outside edge of the Hall effect device and the inside edge of the magnet.

The 2.3L DP PIP cup has two teeth or vanes and generates two high PIP signals per crankshaft revolution (Figure 3-23). Base timing is 10° BTDC, therefore, a vane cup is aligned so that the leading edge of a PIP signal occurs 10° before pistons 1 and 4 reach TDC. The signal is ON for 90° of crankshaft rotation. The signal is then OFF or low for 90° of crankshaft rotation.

The leading edge of the next PIP signal occurs 10° before pistons 3 and 2 reach TDC and the signal continues for 90° of crankshaft revolution. The PIP signal is OFF for the final 90° of crankshaft rotation. This, of course, is a 50% duty cycle which results in a digital square wave.

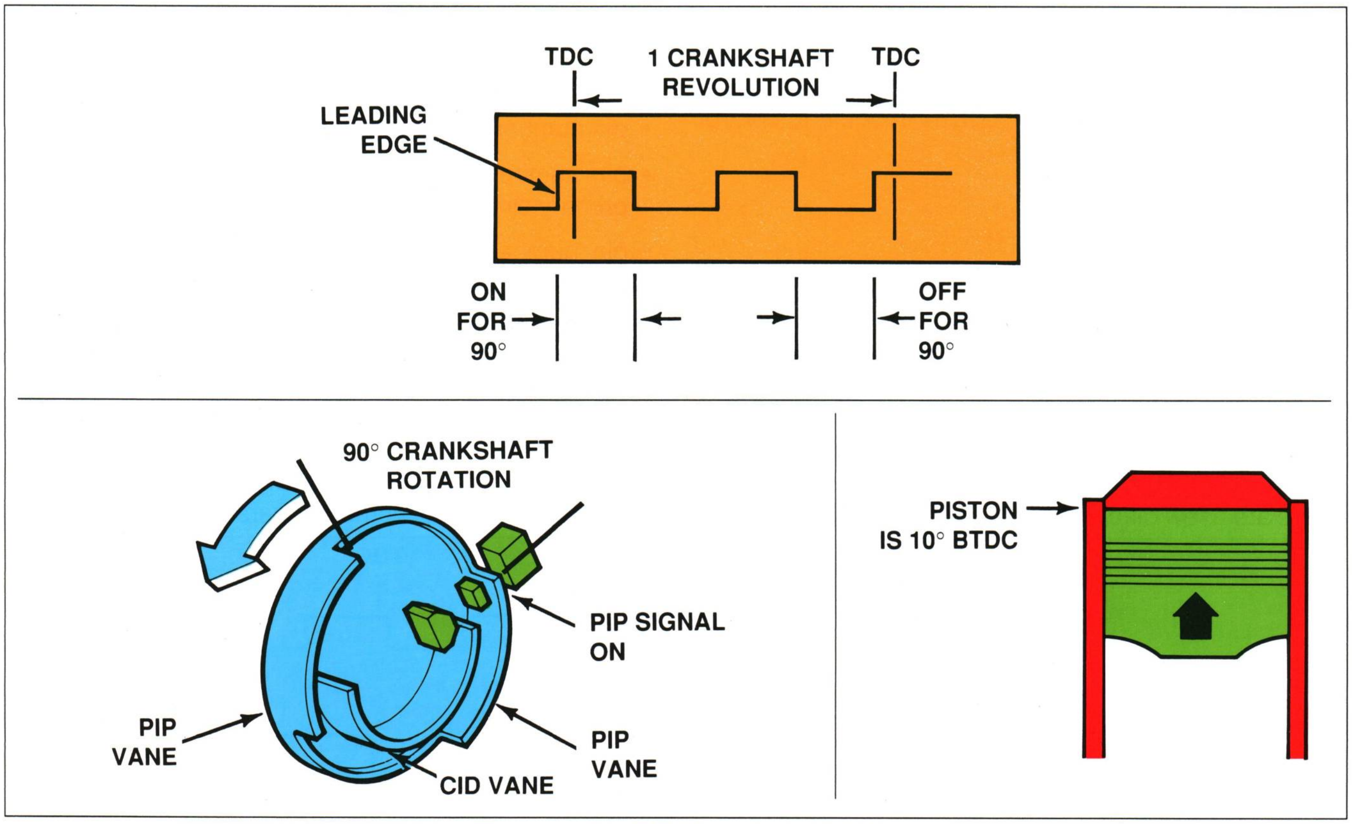


Figure 3-23. PIP Signal - 2.3L DP

The CID cup has one tooth (Figure 3-23) and generates one high CID signal per crankshaft revolution, or two high signals per camshaft revolution. The vane cup is aligned so that the leading edge of the CID signal occurs 10° after piston 1 reaches TDC. The signal is ON for 180° of crankshaft rotation. The CID signal is OFF for the remaining 180° of crankshaft rotation (Figure 3-24).

Note that DIS completes one ignition cycle for each revolution of the crankshaft. However, it takes two revolutions of the crankshaft to fire every cylinder and complete the four stokes of an engine cycle.

REMEMBER THE FOLLOWING FOR THE 2.3L DP DIS:

- the dual Hall sensor contains both the PIP and CID sensors.
- two high PIP signals are produced each crankshaft revolution.
- a leading edge of PIP occurs 10° before a piston reaches TDC.
- one high CID signal is produced each crankshaft revolution; two each camshaft revolution.
- a leading edge of CID occurs 10° after piston 1 reaches TDC.

CONTROLLERS - 2.3L DP

Like the 3.8L SC and 3.0L SHO, the 2.3L DP DIS uses a DIS ignition module and the EEC-IV module to control ignition.

DIS Ignition Module

FUNCTION

The DIS module for the 2.3L DP DIS performs the same six functions as the DIS module in the 3.8L SC and 3.0L SHO system. Plus the 2.3L DP DIS module relays the PIP signal to the EEC-IV module and responds to the DPI commands from the EEC-IV module.

COMPONENTS

There are a few differences in the DIS module. The 2.3L DP DIS module contains four (instead of three) output drivers. Each output driver still completes the ground path for one coil within a coil pack. This DIS module also uses circuitry to relay the PIP signal and receive the DPI signal.

OPERATION

The 2.3L DP DIS module also has two six-pin connectors to the DIS harness. The 2.3L DP uses three pins not used in the 3.8L SC and 3.0L SHO DIS. The three pins used are for PIP output to the EEC-IV module, Dual Plug Inhibit (DPI) input from the EEC-IV module, and to provide the ground path for an additional coil output.

One connector provides the following:

- pin number one provides battery voltage to the DIS module.
- pin number two provides CID sensor input.
- pin number three provides PIP to the EEC-IV module.
- pin number four provides for PIP sensor input to the DIS module.
- pin number five provides the SPOUT input from the EEC-IV module.
- pin number six provides DPI input from the EEC-IV module.

The second connector provides the following:

- pin number seven provides ignition ground (IGND).
- pin number eight provides the ground path for the primary circuit of coil 3.
- pin number nine provides the ground path for the primary circuit of coil 4.
- pin number ten provides the ground path for the primary circuit of coil 2.
- pin number eleven provides the ground path for the primary circuit of coil 1.
- pin number twelve provides IDM output to the EEC-IV module and for tachometer operation.

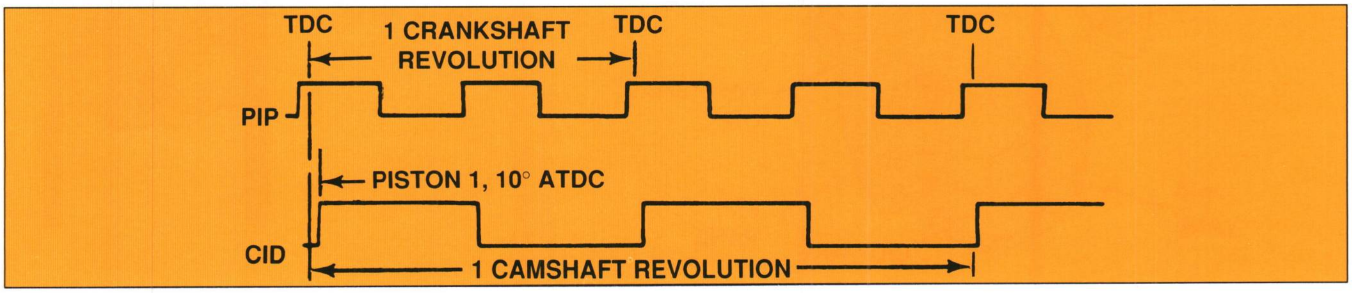


Figure 3-24. CID and PIP Signal Frequencies - 2.3L DP

The 2.3L DP DIS ignition module performs the following five functions in basically the same manner as the 3.8L SC and 3.0L SHO system:

- provides ignition ground (IGND).
- selects which coil within a coil pack to fire.
- limits coil primary current to 5.5 amps (± 0.5 amps).
- generates IDM signal.
- provides FMEM.

CHOOSING A COIL TO FIRE

The 2.3L DP DIS ignition module operates similar to the six-cylinder module to determine which coil to fire and to fire the coil. The DPI signal is used to operate the left coil pack. The 2.3L DP system uses the CID signal and the DPI signal to determine which coils to fire.

During engine start-up, the DPI signal from the EEC-IV module is 12 volts. The DIS module inhibits dual plug operation and only the right coil pack operates (Figure 3-25). Once the engine is running, the DPI signal to the DIS module is zero volts and the right and left coil packs operate. When DIS is in this dual plug mode, the left coil pack operates in parallel with the right coil pack (Figure 3-26).

During engine start-up and when the engine is running, SPOUT determines when to fire the coils and CID is used to determine which coils to fire. If the SPOUT circuit opens, then PIP is used to determine when to fire the coils.

EEC-IV Module - 2.3L DP

The 2.3L DP EEC-IV module performs basically the same ignition functions as the 3.8L SC and 3.0L SHO EEC-IV module with the following differences:

- the PIP signal is received from the DIS module, not the PIP sensor.
- no CID signal is sent to the EEC-IV module because the 2.3L DP engine does not use sequential fuel injection.
- determines if the engine should be in single or dual plug operating mode and sends the DPI signal to the DIS module.
- in addition to the diagnostic information, IDM tells the EEC-IV module if the engine is in single or dual plug mode.

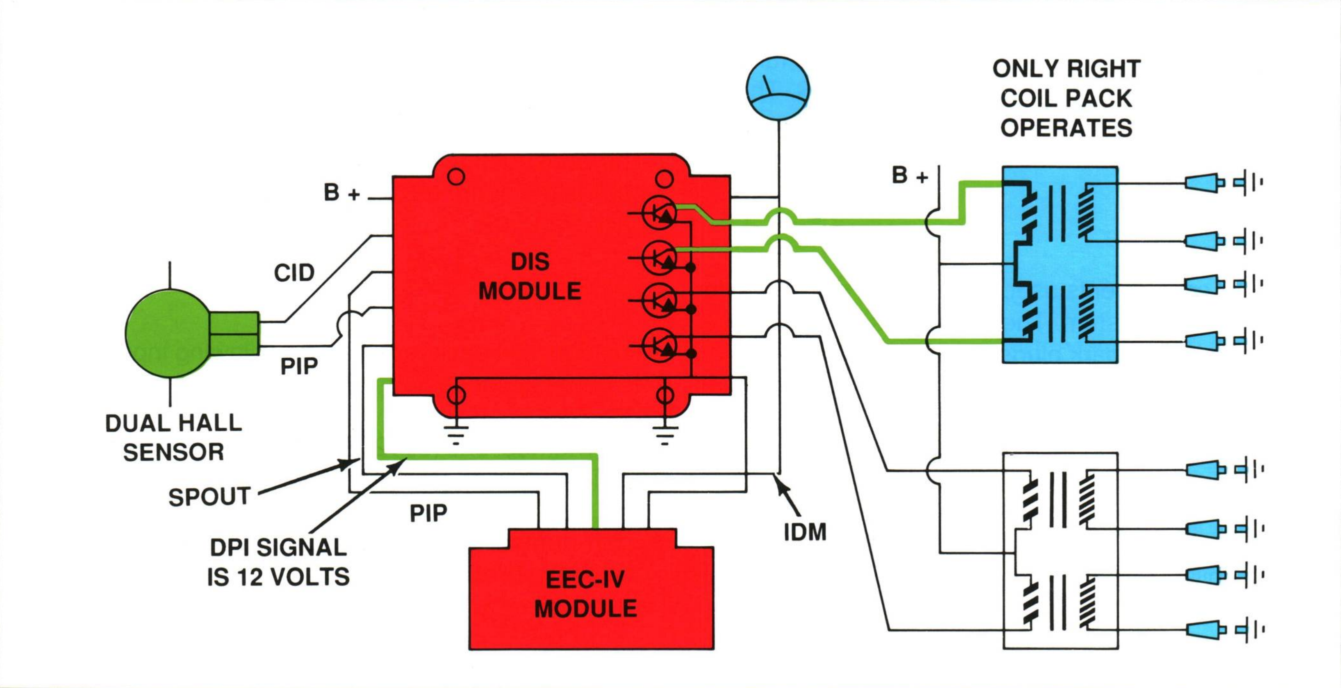


Figure 3-25. DPI 12 Volts - Single Plug Mode - 2.3L DP

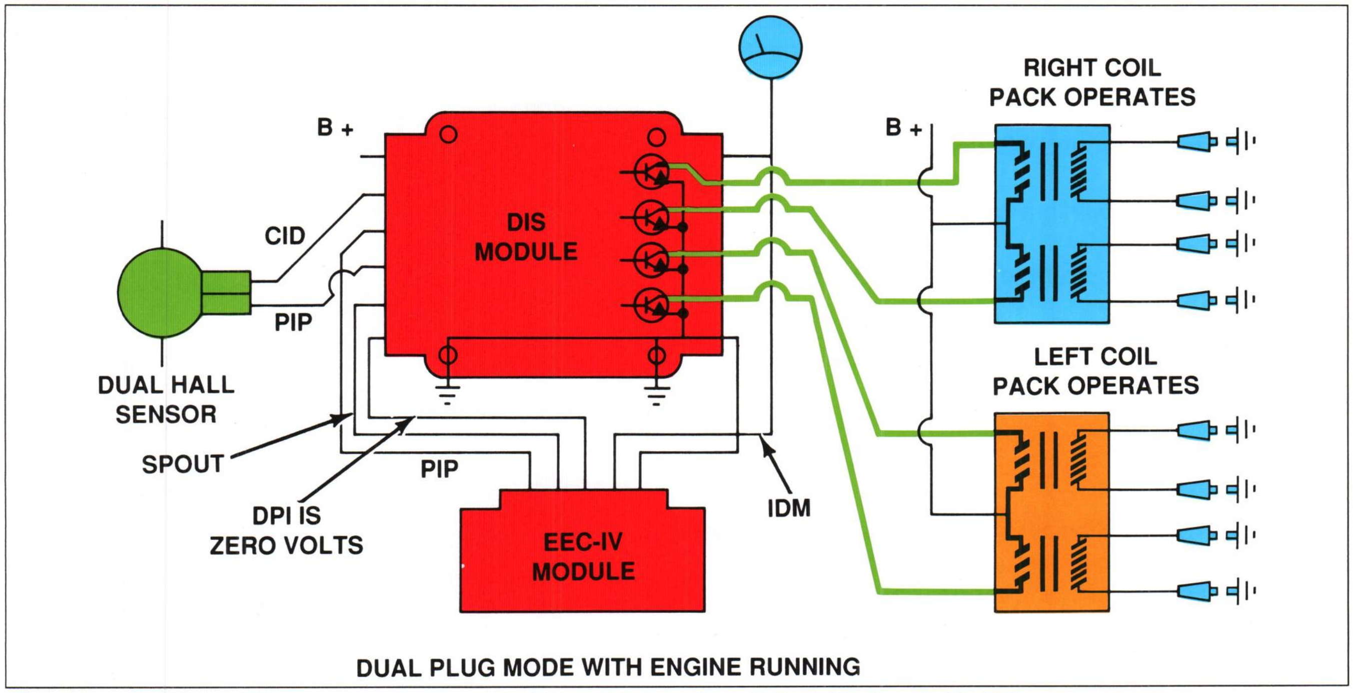


Figure 3-26. DPI Zero Volts - Dual Plug Mode - 2.3L DP

OUTPUT DEVICES - 2.3L DP

DIS Coils

FUNCTION

The coils for the 2.3L DP DIS perform the same function as the coils for the 3.8L SC and 3.0L SHO DIS. That is, they provide the high voltage spark needed to ignite the air/fuel mixture in the combustion chamber.

COMPONENTS

The actual components used is the major difference for the 2.3L DP coil system. The 2.3L DP is a four-cylinder engine with eight spark plugs; two spark plugs for each cylinder. Like the six-cylinder DIS coil pack, each coil has two high voltage towers and supplies high voltage for two plugs. Therefore, the 2.3L DP requires four coils.

Two coil packs are used. Each contains two coils and four high voltage towers (Figure 3-27). The right coil pack contains coils 1 and 2. The right coil pack is mounted on a bracket bolted to the right front corner of the cylinder head assembly (Figure 3-21). The coil pack is located next to the right front edge of the cylinder head assembly; slightly forward and below the oil fill cap.

The left coil pack contains coils 3 and 4. The left pack is mounted on a bracket bolted to the lower left front of the cylinder block (Figure 3-21). The coil pack is located forward and slightly below the engine oil filter.

The construction of the individual coils within the coil pack is the same as the coil used in the six-cylinder coil pack.

OPERATION

The right coil pack receives the following inputs through its harness connector:

- pin number one (coil 2 primary) is the ground path to pin number ten of the DIS module.
- pin number two provides battery voltage for the coil primary circuits.

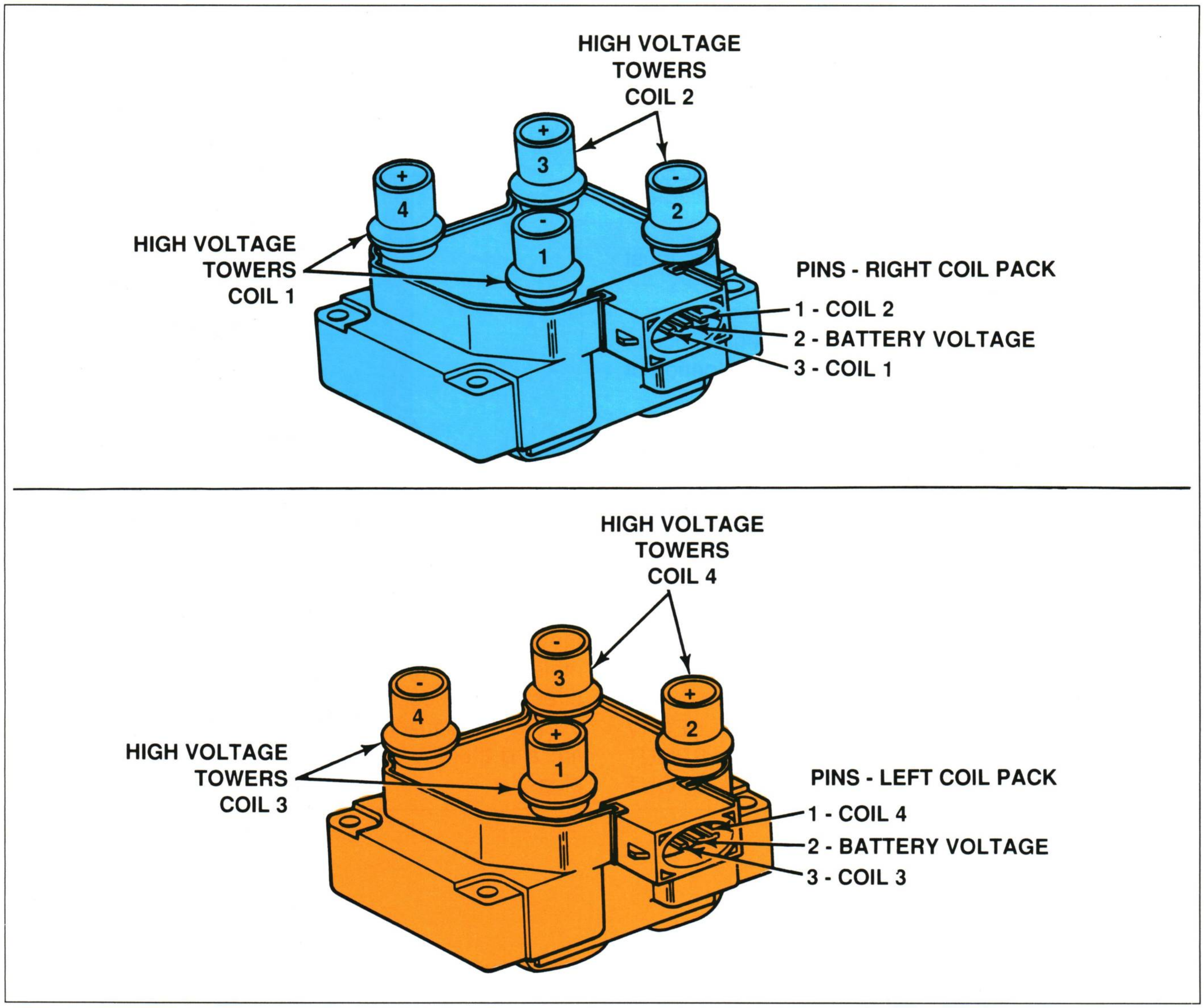


Figure 3-27. Coil Packs - 2.3L DP DIS

- pin number three (coil 1 primary) is the ground path to pin number eleven of the DIS module.

The left coil receives the following inputs through its harness connector:

- pin number one (coil 4 primary) is the ground path to pin number nine of the DIS module.
- pin number two provides battery voltage for the coil primary circuits.
- pin number three (coil 3 primary) is the ground path to pin number eight of the DIS module.

The coils within the coil packs operate in the same manner as the coils in the six-cylinder DIS. The coil primary current is limited to 5.5 amps (± 0.5 amp). The current induced into the secondary circuit results in a minimum of 32,000 volts.

DIS Spark Plugs - 2.3L DP

The only difference in the 2.3L DP system is that eight standard spark plugs are used. Like the six-cylinder DIS, two plugs are wired in series with one coil. One plug always fires from center electrode to side electrode while its companion plug fires from side electrode to center electrode.

DIS OPERATION

INTRODUCTION

In this section we will explain the operation of DIS. First, we will describe DIS operation on the 3.8L SC and 3.0L SHO engines. Then we will describe the 2.3L DP ignition system and how it differs from the 3.8L SC and 3.0L SHO system.

Of course for an engine to run, the air/fuel mixture must be ignited during the compression stroke.

As you know, in order for a "combustion event" to occur, the following must take place within a specific period of time (Figure 4-1).

- The air/fuel mixture must be present in the combustion chamber of the cylinder that is in the compression stroke.
- The piston must be approaching TDC of its compression stroke.
- A high voltage spark must jump the gap of the spark plug of the cylinder that is in the compression stroke.

To accomplish this combustion event, the EEC-IV module controls the fuel injectors and sends a SPOUT signal to the DIS module. As in TFI-IV systems, SPOUT tells the ignition module when to fire the coil. However, TFI-IV uses one E-core coil and a distributor to provide the high voltage spark to the plugs (Figure 4-2). DIS uses multiple coils, with each coil supplying high voltage directly to a specific pair of spark plugs. The DIS module uses a CID sensor to determine which particular coil to fire and thereby distribute spark to the correct pair of plugs.

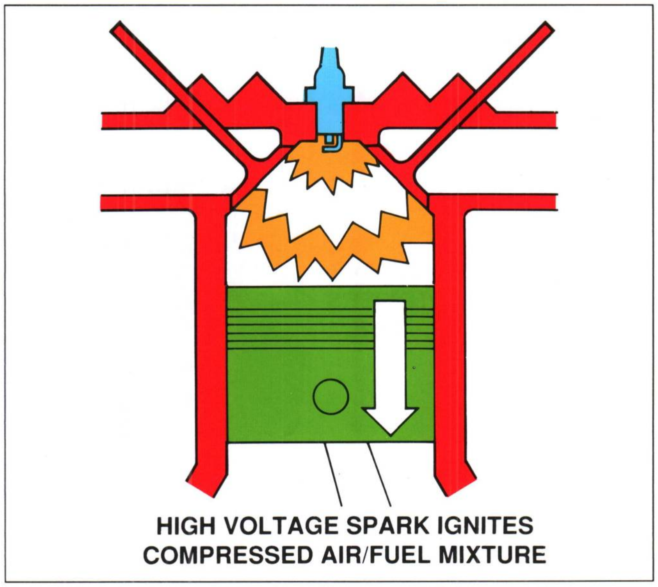


Figure 4-1. Combustion Event

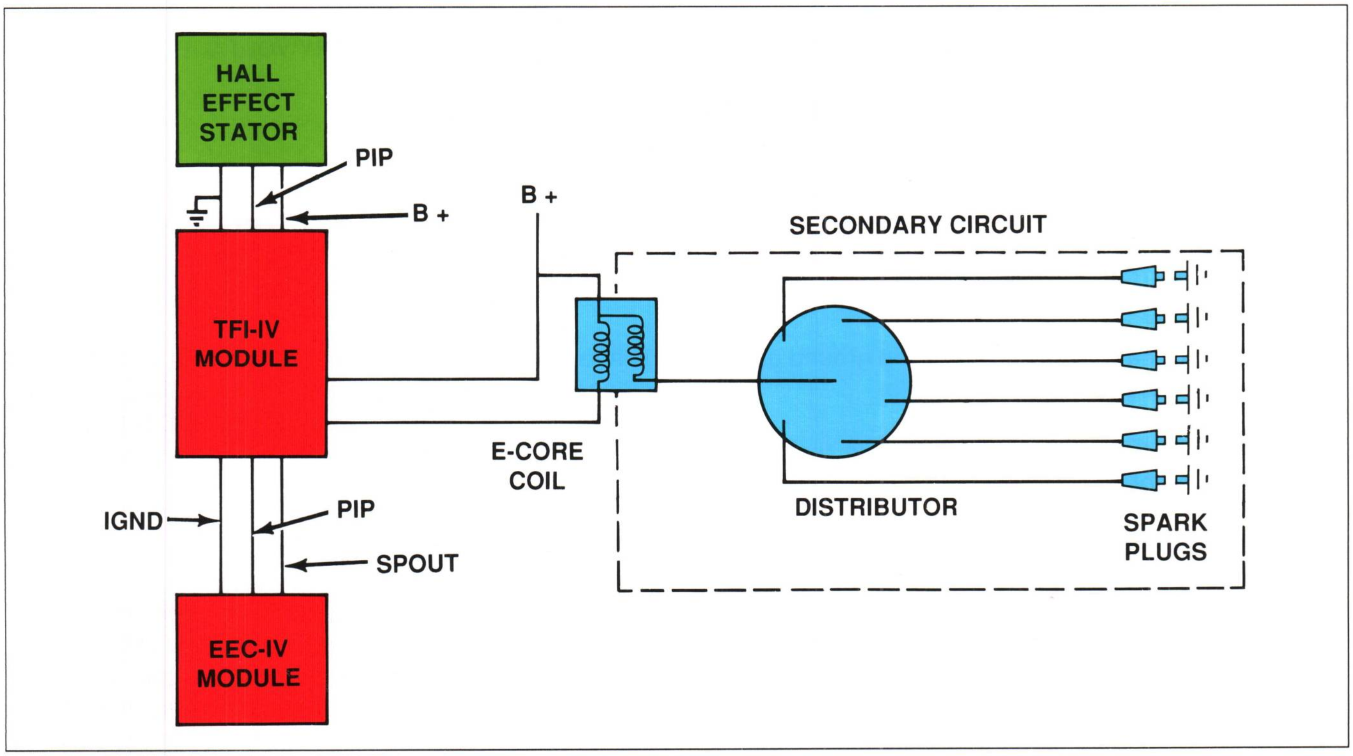


Figure 4-2. TFI-IV Ignition System

DIS COMPONENTS - 3.8L SC AND 3.0L SHO

DIS consists of the following (Figure 4-3):

- DIS ignition module.
- camshaft driven CID sensor.
- a crankshaft mounted PIP sensor.
- a DIS coil pack which contains three coils and six, high voltage towers.
- six spark plugs and wires.
- a primary circuit.
- a secondary circuit.
- the EEC-IV module which interacts with the DIS module.

DIS OPERATION - 3.8L SC AND 3.0L SHO

ENGINE CRANKING

During crank, engine, fuel, and ignition controls are different compared to when the engine is running. At start-up, the EEC-IV module uses a predetermined fuel control strategy to supply fuel to the cylinders. After the engine is running, the fuel injectors fire sequentially.

As the engine cranks, DIS monitors CID and SPOUT. At the same time, the EEC-IV module fires the fuel injectors so fuel is available for combustion.

The DIS module looks for a transition in the CID signal, either a leading edge or a trailing edge. Keep in mind, there is no current to any coil at this time. Immediately after this CID transition, DIS uses the first trailing edge of SPOUT to turn ON coil 2 primary current. DIS uses the next SPOUT leading edge to turn OFF coil 2 primary, or fire coil 2.

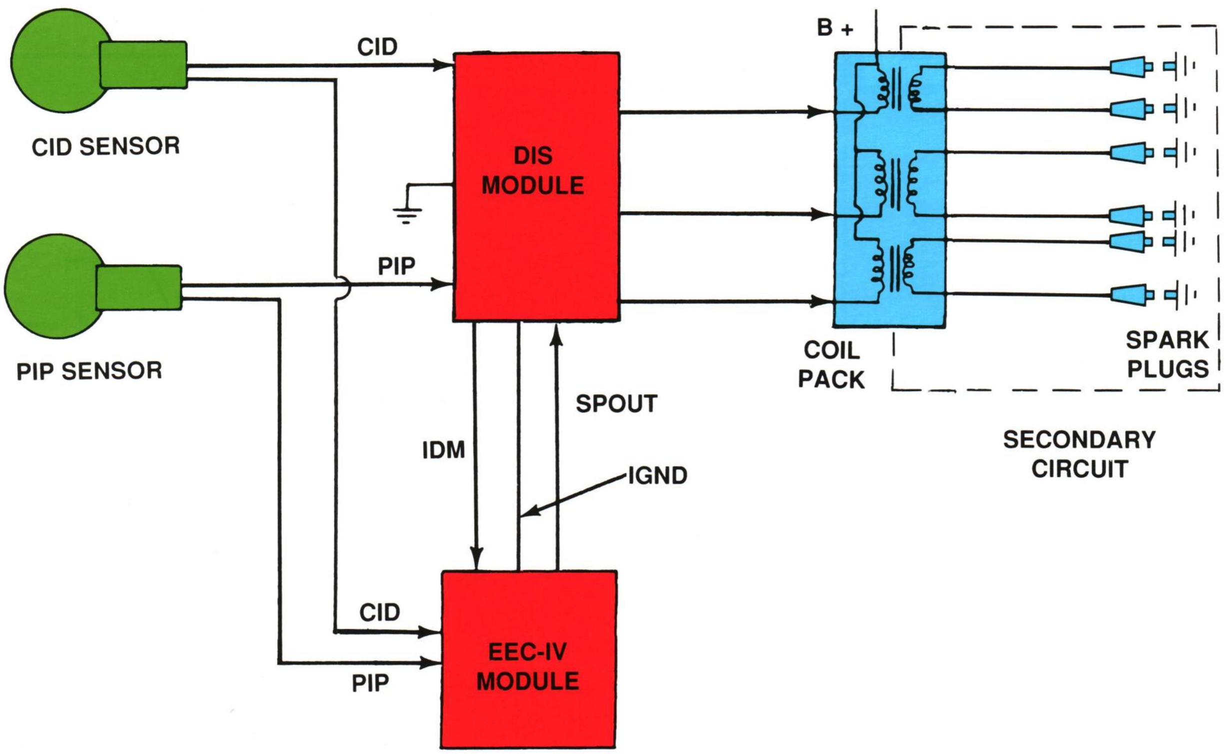


Figure 4-3. DIS 3.0L SHO and 3.8L SC

As discussed in "DIS COMPONENTS," the DIS module fires the coils in sequence. Therefore, the next trailing edge of SPOUT turns coil 3 primary ON and the next SPOUT leading edge fires coil 3. Then, of course, the next SPOUT trailing edge turns coil 1 primary ON and the leading edge turns coil 1 primary OFF (Figure 4-4).

The DIS module receives three high SPOUT signals for each revolution of the crankshaft. During the same time period, the DIS module sees one transition or change in the CID signal. In other words, a leading edge and a trailing edge of CID occurs for every six SPOUT signals. This is because the camshaft rotates at half the speed of the crankshaft (Figure 4-5).

The leading edge of the CID signal indicates piston 1 is 26° ATDC of its power stroke. This, of course, also means piston 5 is in its intake stroke. The trailing edge of CID indicates piston 1 is in its intake stroke, therefore, piston 5 is in the power stroke (Figure 4-6).

Keep in mind that each coil supplies the high voltage spark for two cylinders. The leading edge of PIP occurs at 10° BTDC. At engine crank, SPOUT provides base ignition timing so the coils are fired at 10° BTDC.

In this example, DIS uses the trailing edge of SPOUT to turn coil 2 primary ON. DIS signals the coil 2 output driver. The output driver in turn completes the ground path,

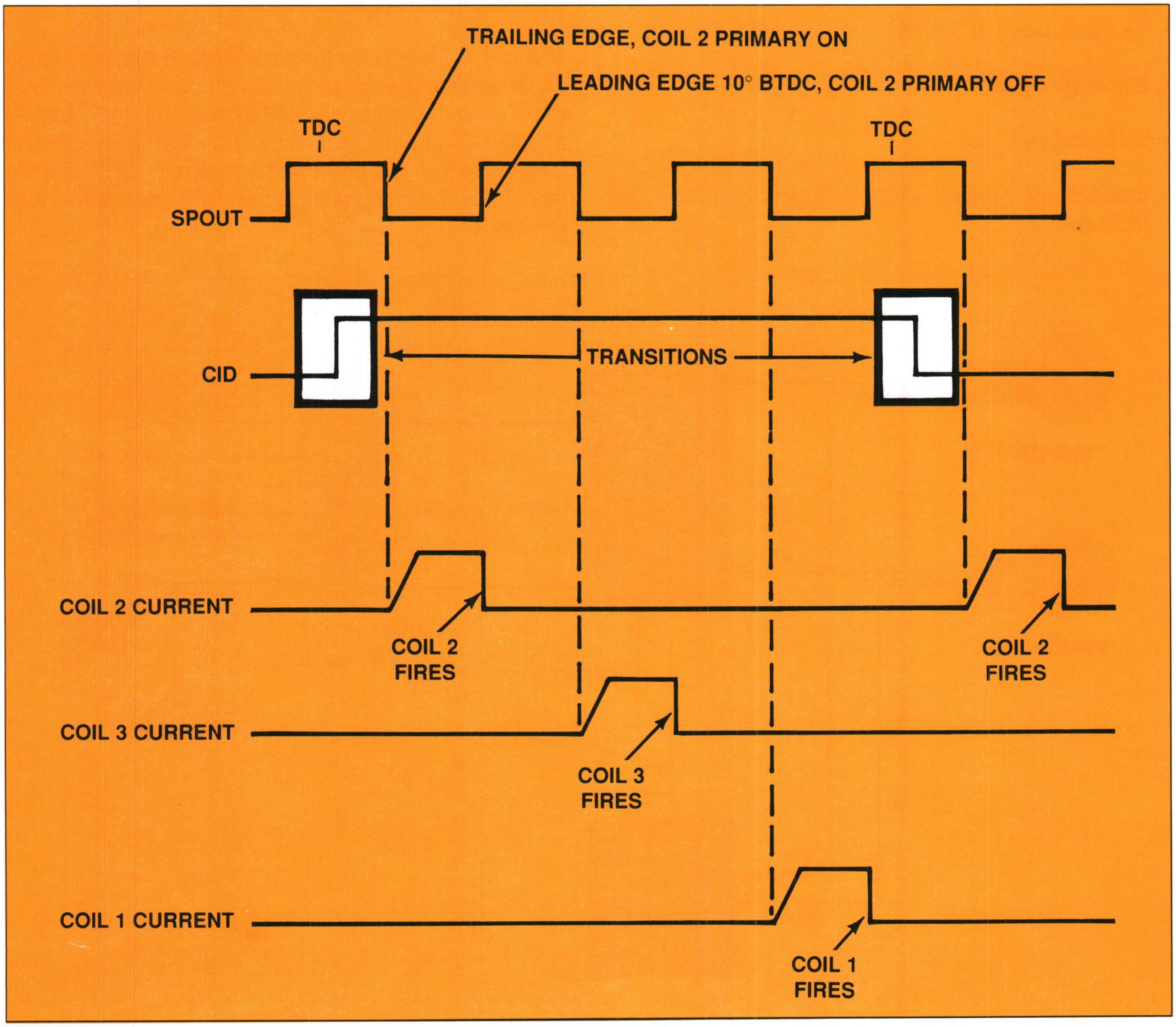


Figure 4-4. DIS at Engine Crank - 3.8L SC and 3.0L SHO

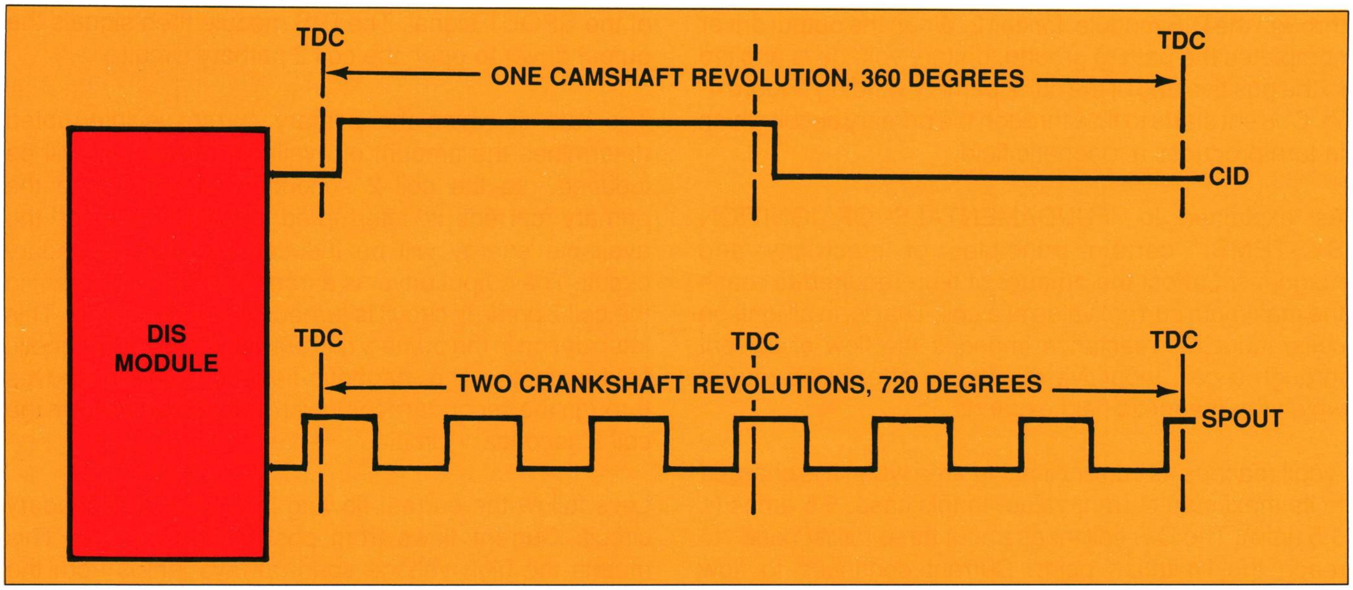

TDC
ONE CAMSHAFT REVOLUTION, 360 DEGREES
TDC
CID
DIS MODULE
TDC
TDC
TDC
TWO CRANKSHAFT REVOLUTIONS, 720 DEGREES
SPOUT

Figure 4-5. CID and SPOUT Frequencies - 3.8L SC and 3.0L SHO

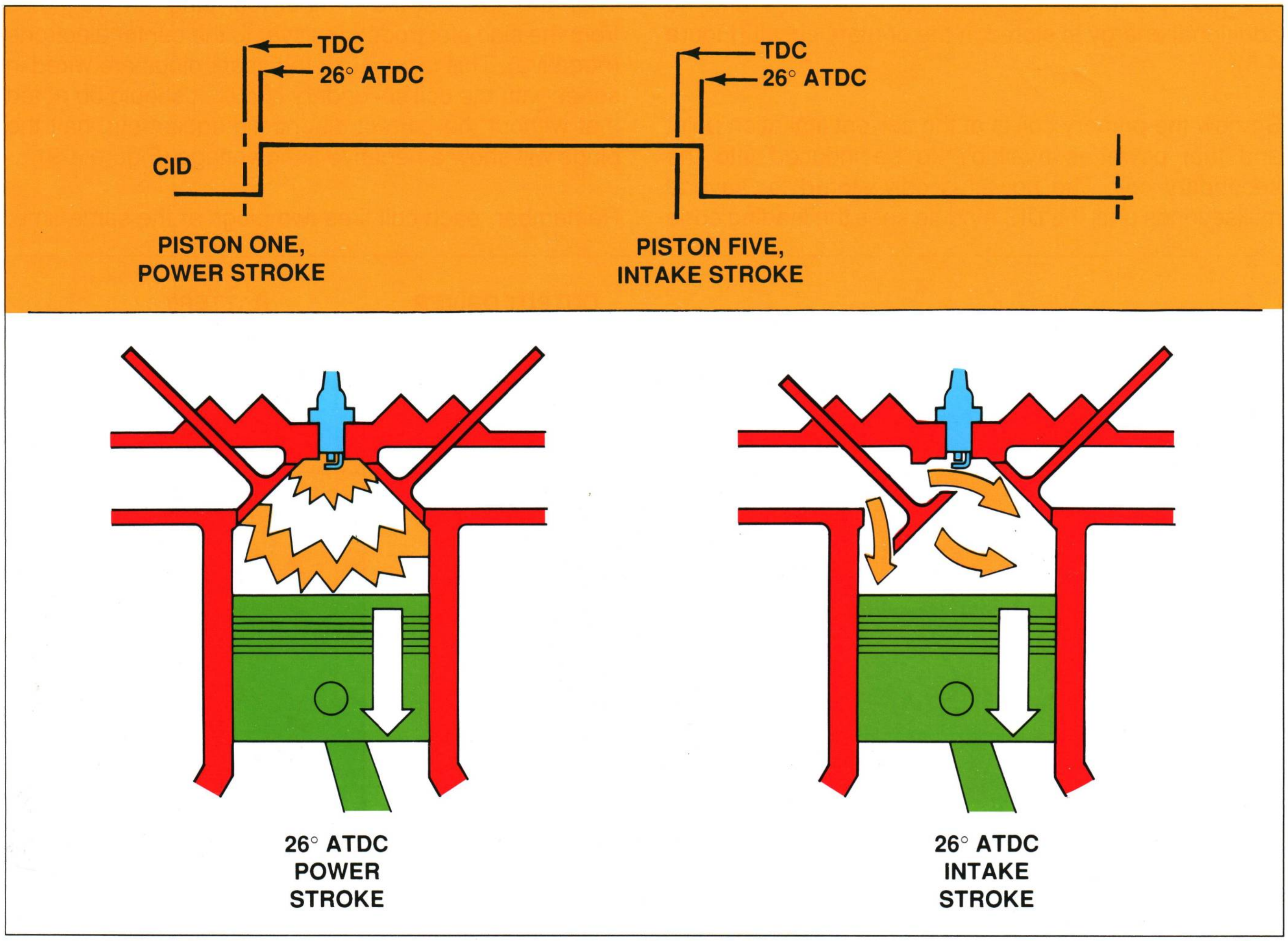


Figure 4-6. CID is 26° ATDC

through the DIS module, for coil 2. When the output driver completes the path to ground, battery voltage is applied to the positive end of the coil 2 primary winding (Figure 4-7). Current starts to flow through the primary circuit which in turn produces a magnetic field.

As explained in "FUNDAMENTALS OF IGNITION SYSTEMS," certain principles of electricity and magnetism affect the amount of time required to reach the maximum current value of a coil. That is, in all ignition coils, inductive reactance impedes the flow of current through a coil. Inductive reluctance affects the rate at which the magnetic field expands.

A coil reaches its current limiting area when it is charged to its maximum current value. In this case, 5.5 amps (± 0.5 amp). The DIS coil takes about three milliseconds to reach the limitation point. Current continues to flow through the primary circuit until the DIS module turns the current OFF. However, once the coil reaches its current limitation point, the magnetic field stabilizes and no additional energy is stored in the primary circuit (Figure 4-8).

So now the primary coil is at the current limitation point and that power is available to be induced into the secondary coil. The power is only stored for several milliseconds until the DIS module sees the leading edge of the SPOUT signal. The DIS module then signals the output driver to open the coil 2 primary circuit.

The rate at which the primary current is interrupted determines the amount of available power that will be induced into the coil 2 secondary circuit. When the primary current is interrupted quickly, more of the available energy will be induced into the secondary circuit. The output driver is a transistor, so the current in the coil 2 primary circuit is turned OFF immediately. This interruption in the primary current collapses the magnetic field instantly. The magnetic field collapses or moves through the secondary coil which induces a current in the coil 2 secondary circuit.

Let's follow the current flowing in the coil 2 secondary circuit. Current flows from positive to negative. This means the high voltage spark always jumps from the center electrode (positive) of the number three plug to the side electrode (negative) of the number three spark plug. Then the spark at the number four plug always jumps from the side electrode (positive) to the center electrode (negative). This is because the spark plugs are wired in series with the coil secondary circuit. It should be noted that without the correct diagnostic equipment, half the plugs will show a negative firing voltage (Figure 4-9).

Remember, each coil fires two plugs at the same time.

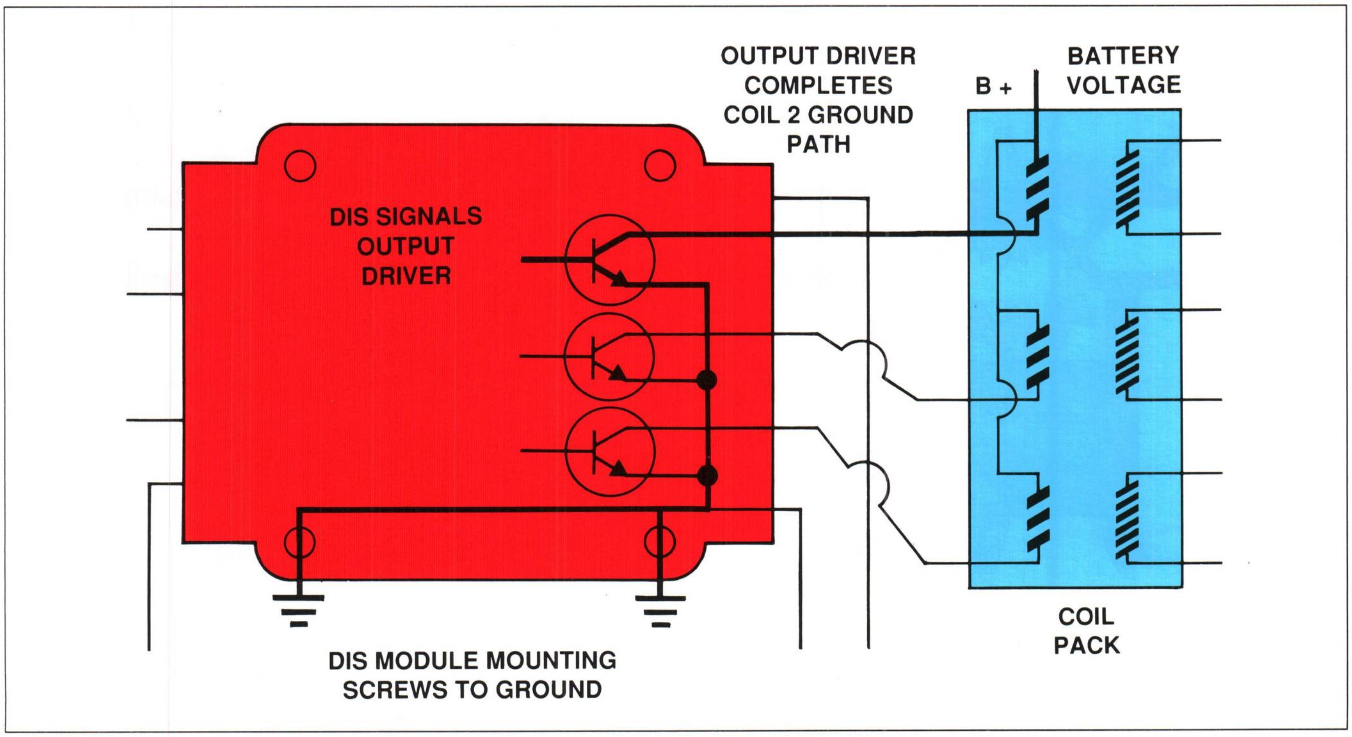

OUTPUT DRIVER COMPLETES COIL 2 GROUND PATH
B +
BATTERY VOLTAGE
DIS SIGNALS OUTPUT DRIVER
COIL PACK
DIS MODULE MOUNTING SCREWS TO GROUND

Figure 4-7. Output Driver Completes Ground Path - 3.8L SC and 3.0L SHO Shown

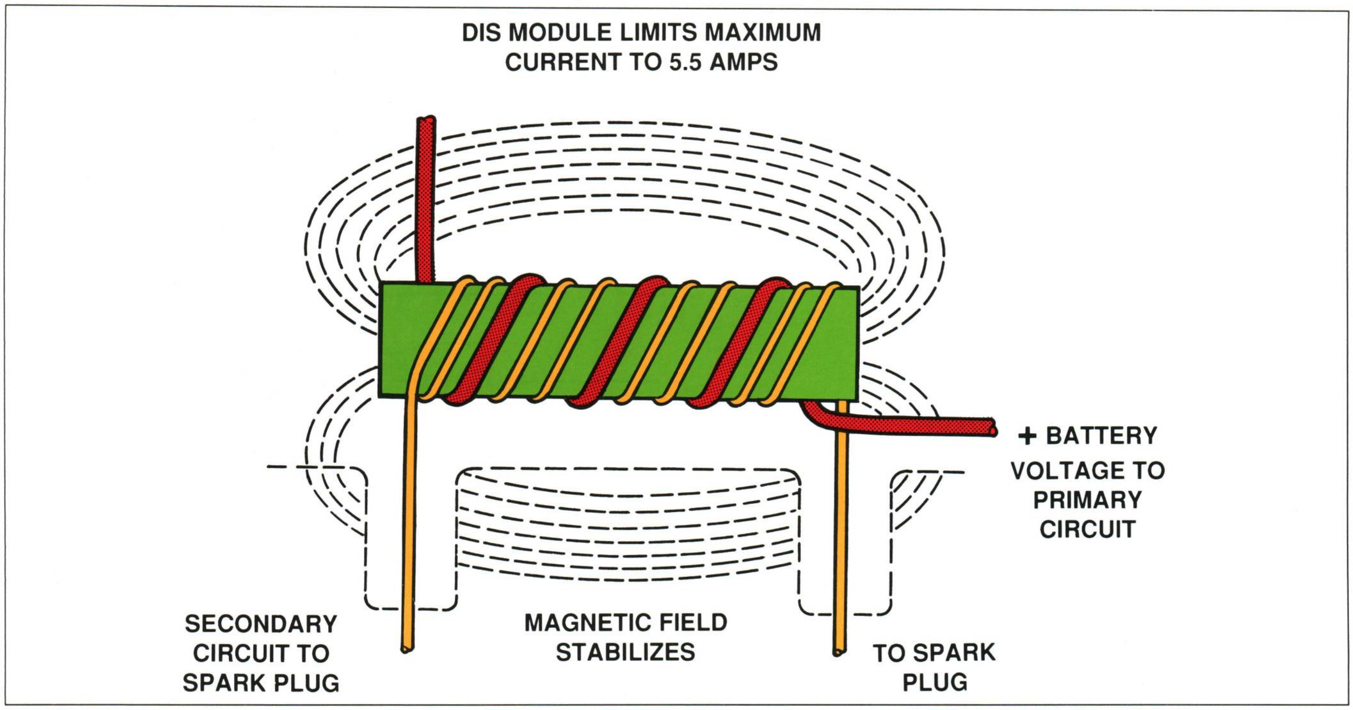

DIS MODULE LIMITS MAXIMUM CURRENT TO 5.5 AMPS
+ BATTERY VOLTAGE TO PRIMARY CIRCUIT
SECONDARY CIRCUIT TO SPARK PLUG
MAGNETIC FIELD STABILIZES
TO SPARK PLUG

Figure 4-8. Coil Maximum Current Value - 5.5 Amps

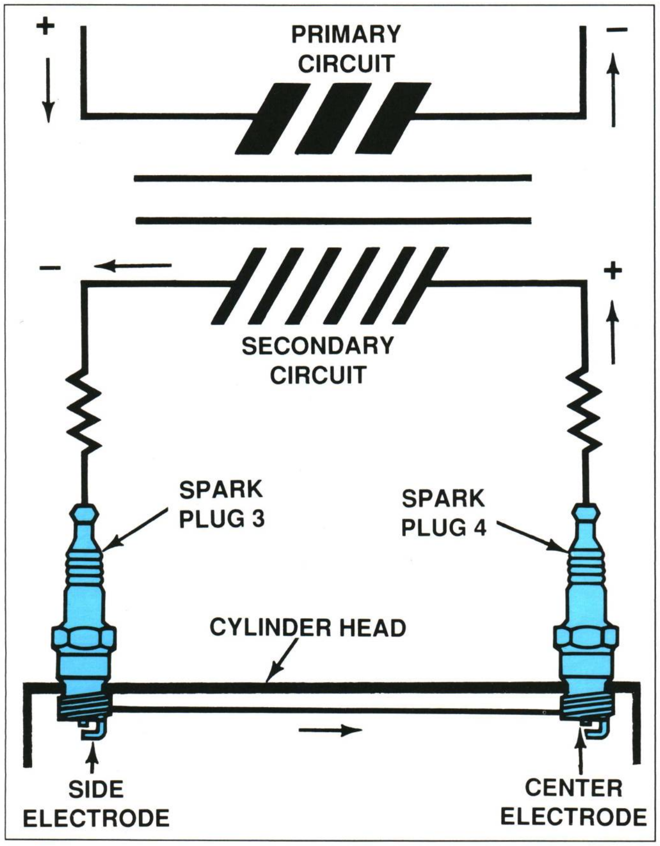


Figure 4-9. Secondary Circuit Wired in Series - 3.8L SC and 3.0L SHO Shown

One plug fires during the compression stroke and its companion plug fires during the exhaust stroke. So in this example of an SEFI engine, cylinder 4 is in compression when the spark, induced by coil 2, jumps the gap to produce that unique combustion event. A high voltage spark also jumps the gap in cylinder 3 which is in its exhaust stroke. The exhaust spark is wasted but little of the coil energy is lost.

At this point, we have seen how the DIS module uses the CID and SPOUT signals to energize the correct coil during engine crank. To keep the engine running, DIS synchronizes the selection of the correct coil with the SPOUT signal. Just as the engine has a specific firing order, the DIS module energizes the coils within the coil pack in a specific sequence. Coil 3 in the coil pack is always fired after coil 2. Coil 1 is always fired after coil 3 and so on (Figure 4-10).

ENGINE RUNNING - 3.8L SC AND 3.0L SHO

The engine has started and the ignition key is in the ON position. Since DIS energizes the coils in a specific sequence, once TDC of cylinder 1 is identified, DIS does not need to use the CID signal to select a coil. The DIS module continues to monitor CID as a check to ensure coil 2 is the coil that fires after the CID transition.

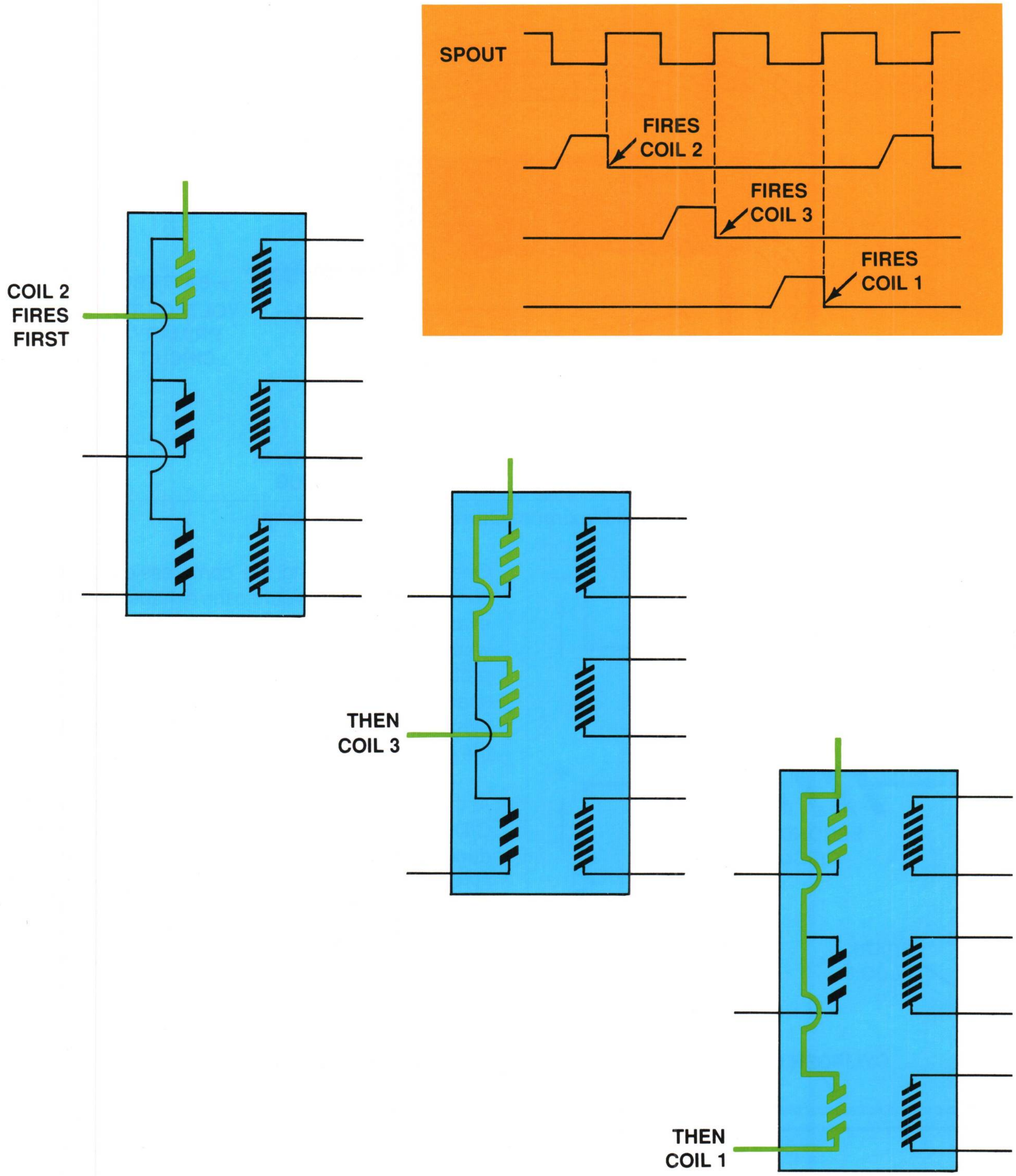


Figure 4-10. Coils Fire in Sequence - 3.8L SC and 3.0L SHO Shown

DIS OPERATION

Remember, on SEFI engines such as the 3.8L SC and 3.0L SHO, a fuel injector is energized as the intake valve opens for that cylinder. For example, as the intake valve for cylinder 1 opens, the fuel injector at cylinder 1 is energized. The EEC-IV module uses CID to synchronize fuel needs on SEFI engines. CID identifies piston 1 at 26° ATDC of the power stroke. The EEC-IV module uses this information to fire the correct fuel injector at the correct time. The DIS module controls the distribution of the spark required to ignite the compressed air/fuel mixture.

In addition, since EEC-IV determines SPOUT, DIS does not use the PIP signal during normal engine operating conditions. EEC-IV does monitor PIP to establish base timing. Besides PIP, EEC-IV monitors other engine sensors in order to determine proper spark timing. In regard to the ignition system, the primary function of the EEC-IV module is to adjust the SPOUT signal to advance or retard the timing, thereby providing the best engine operation.

Using the PIP signal to establish base timing and input from other engine sensors, EEC-IV generates the optimum spark timing output called SPOUT. SPOUT is a digital signal with a variable duty cycle. The spark angle is determined by the leading edge of the SPOUT signal. The trailing edge controls when the coil primary current should be ON. That is, SPOUT represents dwell. This feature is known as computer controlled dwell (CCD) (Figure 4-11). SPOUT is applied to the switching amplifier in the DIS module. The EEC-IV module sends three SPOUT signals to the DIS module for each revolution of the crankshaft. SPOUT tells DIS when to energize a coil primary circuit.

To determine SPOUT, EEC-IV monitors a variety of sensors that affect spark timing, including (Figure 4-12):

- PIP for engine RPM and crankshaft position information.
- mass airflow (MAF) sensor to directly measure the mass of the air being drawn into the engine by volumetric displacement.
- engine coolant temperature (ECT) sensor.
- air charge temperature (ACT) sensor.
- EGR sensor (EVP or PFE) to measure the EGR flow rate.
- throttle position (TP) sensor.
- manifold absolute pressure (MAP) sensor for engine load conditions (2.3L DP only).
- knock sensor (KS).

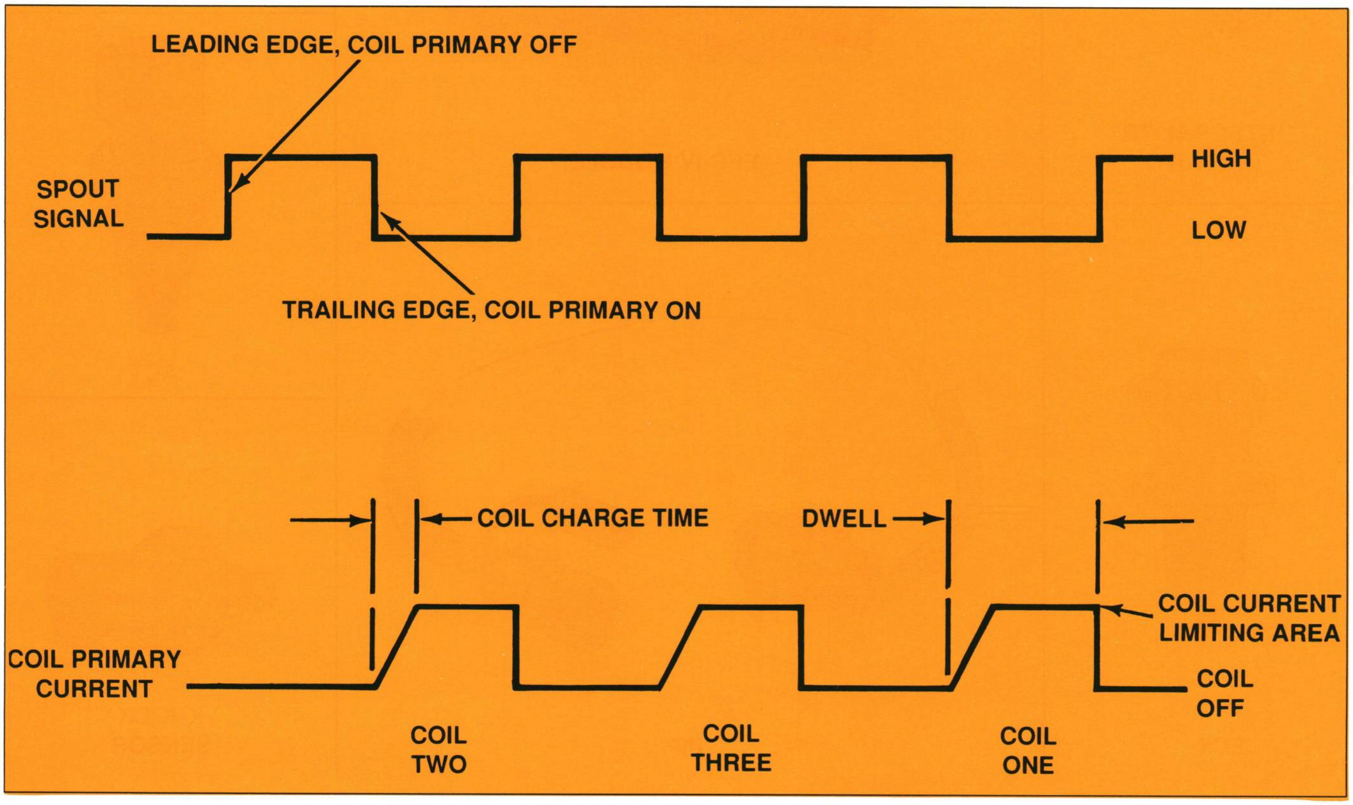


Figure 4-11. Computer Controlled Dwell (CCD)

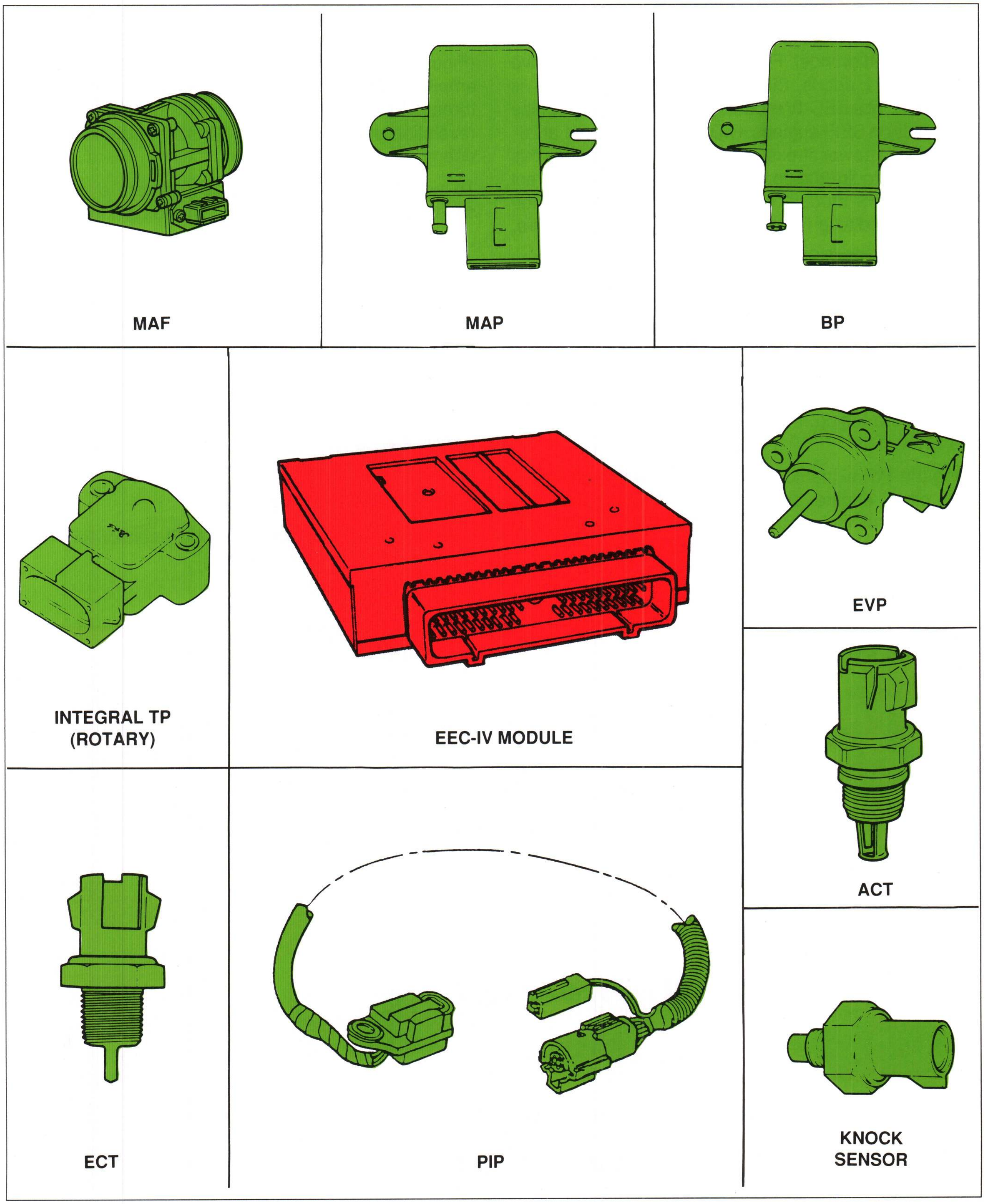


Figure 4-12. EEC-IV Monitors Sensors

DIS OPERATION

To calculate the optimum spark output, EEC-IV must also consider certain operating characteristics of the engine. Microprocessors within the EEC-IV module include look up tables, calibration tables, and engine operating strategies to provide this reference information.

EEC-IV must consider many factors. For optimum power, peak combustion should occur just after TDC. Some factors are constant and predictable:

- the combustion of the air/fuel mixture occurs at a fixed rate.
- it takes an ignition coil a specific amount of time to reach its maximum charge.

Other factors such as engine load and RPM vary or change frequently. As engine speed increases, the ignition coil must be fired earlier so the spark is delivered earlier and peak combustion occurs at the correct time.

As you can imagine, achieving maximum spark for best torque (MBT) is a tough challenge for EEC-IV. Constant spark timing adjustments are needed.

REMEMBER THE FOLLOWING:

- 3.8L SC and 3.0L SHO engine start-up.
  - DIS looks for a CID transition
  - the next trailing edge of SPOUT turns coil 2 ON
  - the next leading edge of SPOUT fires coil 2
  - DIS fires the coils in sequence using SPOUT
  - SPOUT is 10° BTDC which is base timing
- Engine running.
  - SPOUT represents dwell
  - EEC-IV uses CID to synchronize fuel injection
  - CCD provides optimum spark output for various engine operating conditions

DIS COMPONENTS - 2.3L DP

As mentioned earlier, there are differences in the components and operation of the DIS 4-2 system used on 2.3L DP engines, compared to the 3.8L SC and 3.0L SHO SEFI engines. We described DIS operation on 3.8L SC and 3.0L SHO engines. Now we will describe DIS operation on the 2.3L DP engine.

The DIS 4-2 system consist of the following (Figure 4-13):

- a DIS ignition module.
- a crankshaft mounted dual Hall sensor that contains the CID sensor and the PIP sensor.

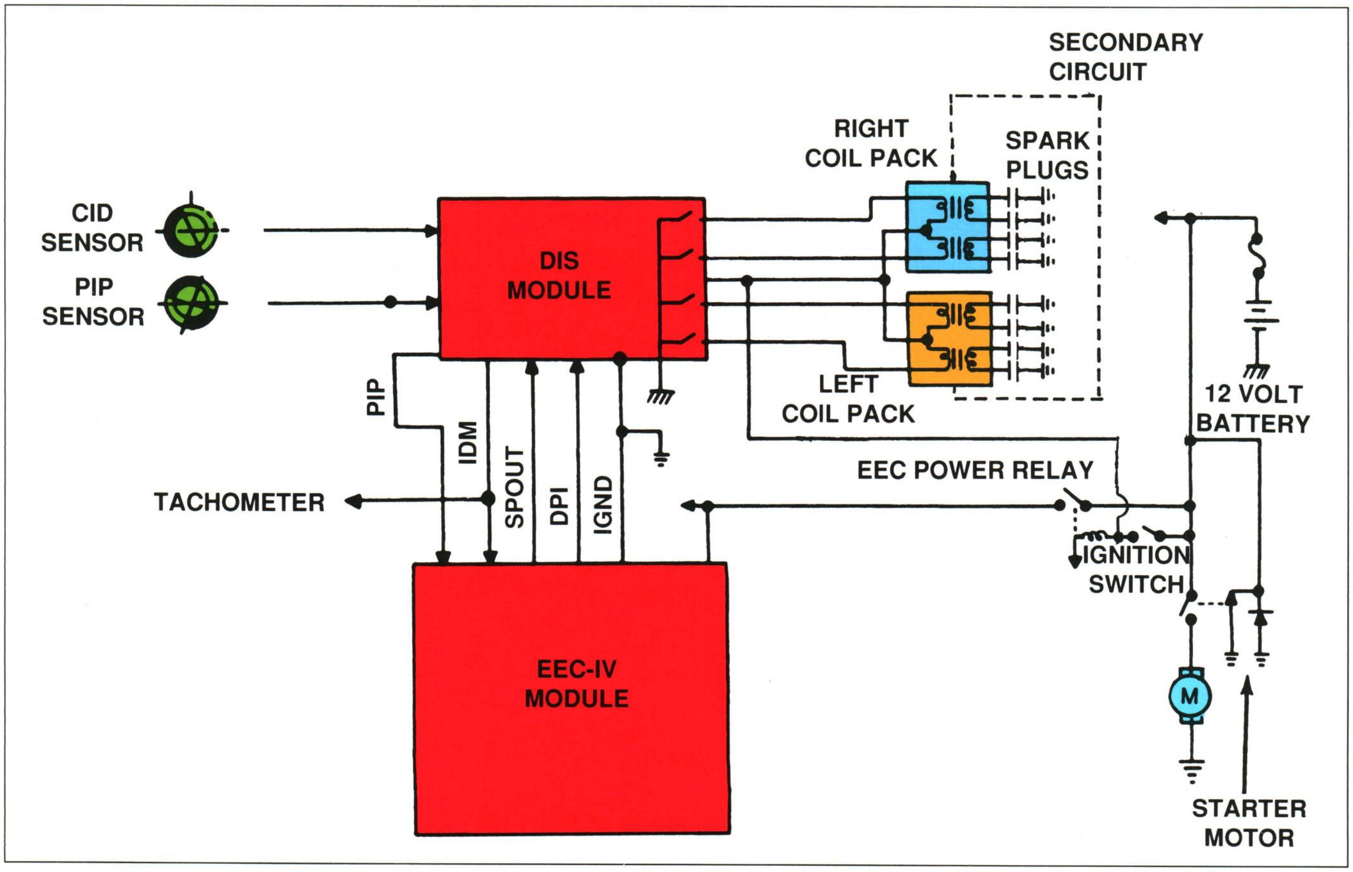


Figure 4-13. Ignition System Components - 2.3L DP

- two DIS coil packs; a right coil pack and a left coil pack.
- eight spark plugs and eight spark plug wires.
- a primary circuit.
- a secondary circuit.
- the EEC-IV module has a dual plug inhibit (DPI) feature and interacts with the DIS module.

2.3L DP FEATURES

Before we describe the operation, consider these facts regarding the 2.3L DP ignition system.

There are two spark plugs per cylinder; a right plug and a left plug. Therefore, two coil packs are required; a right coil pack mounted on the right side of the engine and a left coil pack mounted on the left side of the engine (Figure 3-21).

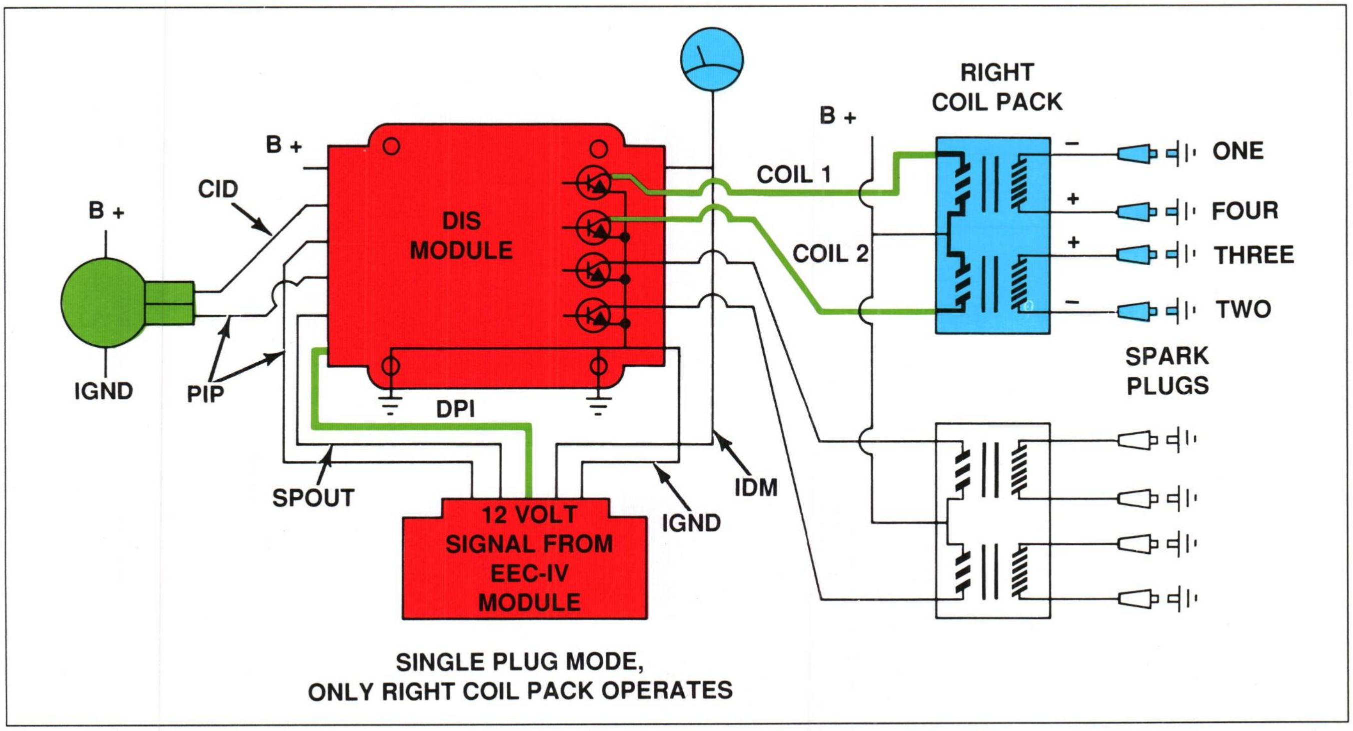
The dual plug inhibit (DPI) feature allows EEC-IV to switch the ignition system from single plug to dual plug operation. Single plug mode is used during engine start-up (Figure 4-14). Dual plug mode is used when the engine is running. During dual plug operation, the right and left coils fire in synch so that the right and left spark plugs fire together. That is, the right spark plugs one and four fire at the same time as the left spark plugs one and four. However, the firing polarity of the left plugs is the reverse of the right plugs. For example, the center electrode of right plug number one is negative but the center electrode of left plug number one is positive (Figure 4-15).

The right coil pack and right spark plugs are used for the single plug mode and always operate.

The left coil pack and left spark plugs may be switched ON and OFF by the EEC-IV module.

Each coil pack contains two coils, and each coil within a coil pack fires two spark plugs at the same time.

The spark plugs are paired so one plug fires during compression and its companion plug fires during exhaust. The next time that coil is fired, the plug that was on exhaust will be on compression and the companion plug will now be on exhaust.



SINGLE PLUG MODE, ONLY RIGHT COIL PACK OPERATES

Figure 4-14. Single Plug Mode at Start-Up - 2.3L DP

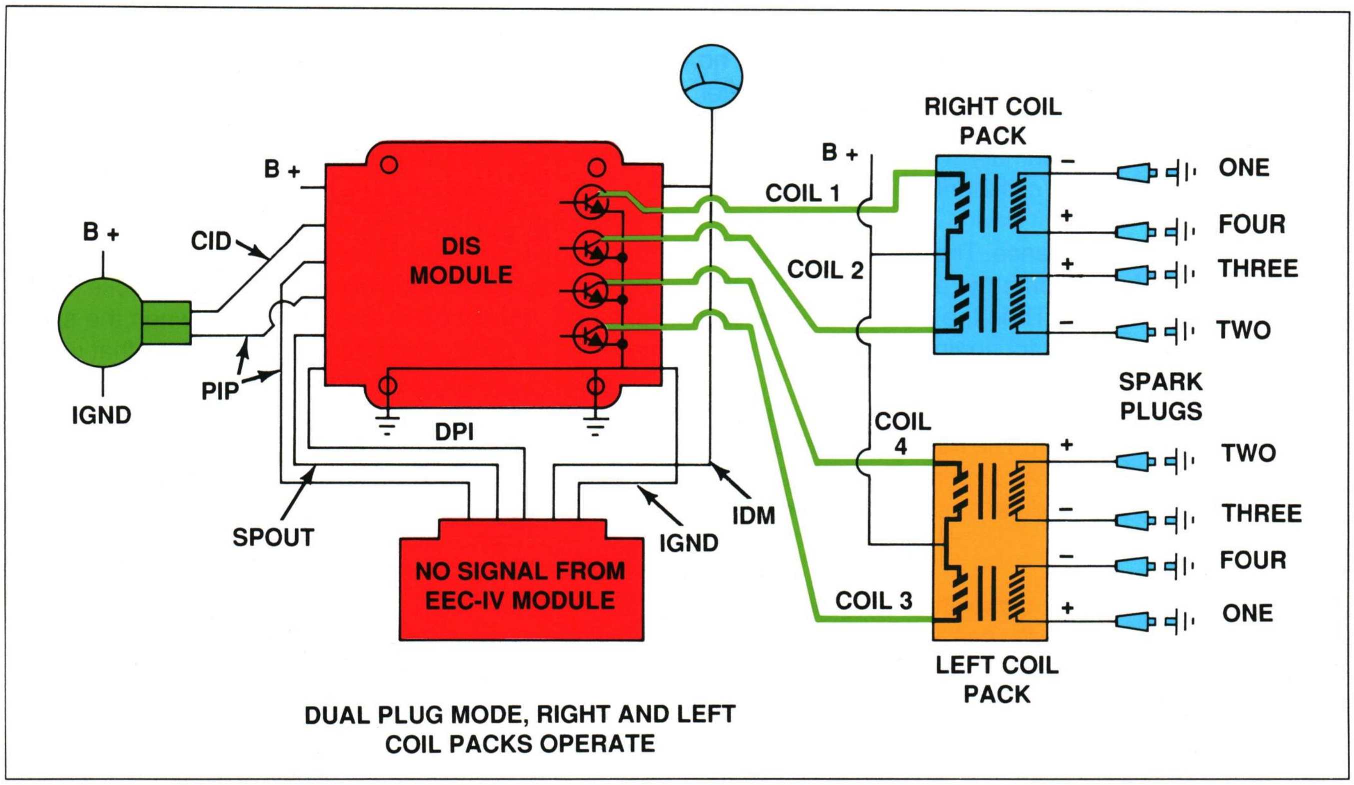


Figure 4-15. Engine Running, Dual Plug Mode - 2.3L DP

The 2.3L DP DIS module uses CID to determine the proper coil to fire in the same way as the 3.8L SC and 3.0L SHO modules.

No CID signal is sent to the EEC-IV module.

The DIS module sends the PIP signal to the EEC-IV module for base timing and engine RPM information.

Now let's see how the 2.3L DP ignition system operates.

DIS OPERATION - 2.3L DP

ENGINE CRANKING

At start-up, the EEC-IV module uses a predetermined fuel control strategy to supply fuel to the cylinders. After the engine is running, the fuel injectors are fired in pairs, once every crankshaft revolution. Also at start-up, the EEC-IV module sends a 12 volt DPI signal to the DIS module, so only the right coil pack operates. The right coil pack contains coil 1 and coil 2.

As the engine cranks, DIS monitors CID and SPOUT (Figure 4-16). At the same time, the EEC-IV module fires the fuel injectors and inhibits the left coil pack.

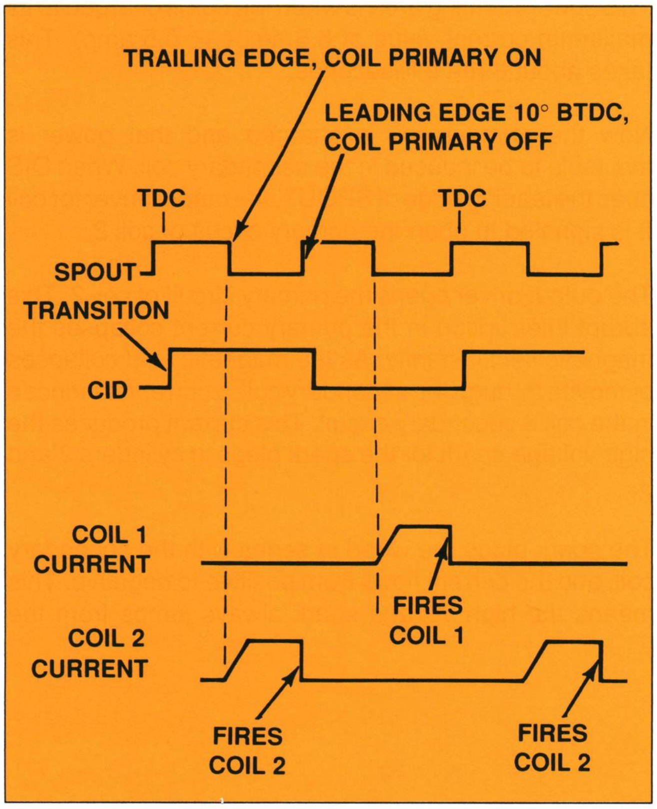


Figure 4-16. DIS at Engine Crank - 2.3L DP

DIS OPERATION

The DIS module looks for a CID transition, either a leading edge or a trailing edge. Of course there is no current to the right coil pack at this time. Immediately after the CID transition, DIS uses the first trailing edge of SPOUT to turn ON coil 2 primary. The next leading edge of SPOUT is used to turn coil 2 primary OFF.

DIS fires the coils in sequence. The next trailing edge of SPOUT turns ON coil 1 primary, and the next SPOUT leading edge fires coil 1. Then the next SPOUT trailing edge turns ON coil 2 primary again and so on.

The DIS module receives two SPOUT signals for each revolution of the crankshaft. The trailing edge of SPOUT is used by DIS to energize a coil primary circuit. The CID signal enables the DIS module to select the proper coil to fire.

The output driver in turn completes the ground path, through the DIS module, for coil 2. Battery voltage is applied to the positive end of the primary winding. Current starts to flow through the primary circuit and the magnetic field begins to expand. As in the 3.8L SC and 3.0L SHO systems, a certain amount of time is required for the coil to reach its current limiting area.

This current limiting area is when the coil is charged to its maximum current value of 5.5 amps (± 0.5 amp). This takes about three milliseconds.

Now the primary coil is charged and that power is available to be induced in the secondary coil. When DIS sees the leading edge of SPOUT, the output driver for coil 2 is signaled to open the primary circuit of coil 2.

The output driver opens the primary circuit of coil 2. This abrupt interruption in the primary current collapses the magnetic field instantly. As the magnetic field collapses or moves through the secondary coil, a current is induced in the coil 2 secondary circuit. This current produces the high voltage spark for the spark plugs in cylinders 2 and 3.

The spark plugs are wired in series with the secondary coil, and the current flows from positive to negative. This means the high voltage spark always jumps from the center electrode (positive) of the number three right plug to the side electrode (negative) of the number three right plug. The high voltage spark at the number two right plug always jumps from the side electrode (positive) to the center electrode (negative) (Figure 4-17).

Since each coil fires two plugs at the same time, one of the plugs is fired during a compression stroke, and its companion plug is fired during an exhaust stroke. In this example, cylinder 3 is in compression when the spark, induced by coil 2, jumps the gap to produce that unique combustion event. Of course a high voltage spark also jumps the gap of the plug in cylinder 2 but little of the coil energy is wasted.

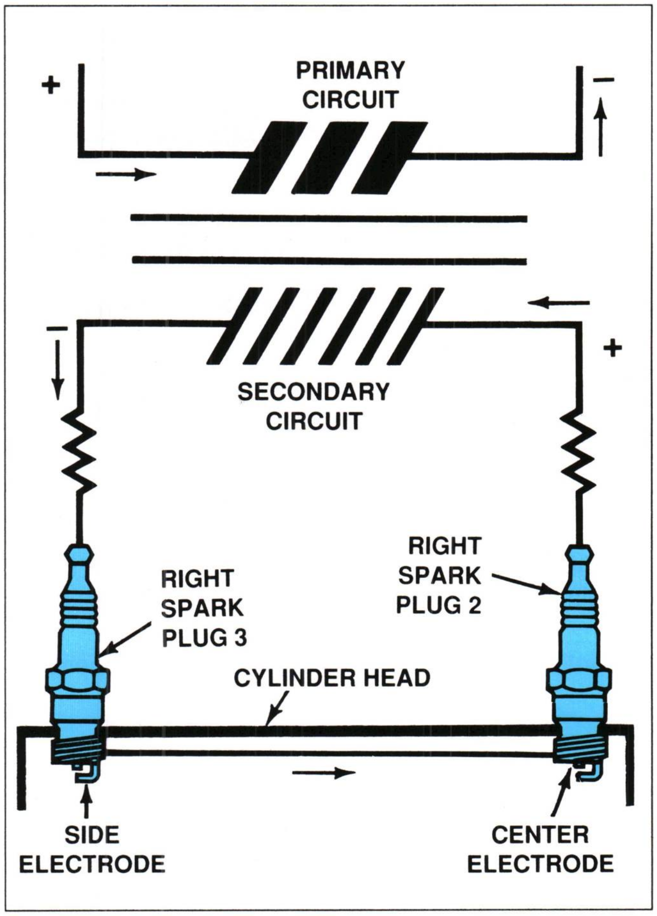


Figure 4-17. Primary and Secondary Current Flow - 2.3L DP Shown

ENGINE RUNNING - 2.3L DP

Now that the engine has started, the DPI signal from the EEC-IV module is zero volts, so the DIS module switches to the dual plug mode. That is, both spark plugs in each cylinder are working because the left and right coil packs are operating.

To keep the engine running, DIS must continue to synchronize its selection of the correct coils with the SPOUT signal. Remember, when the engine is running, DPI is in the dual plug mode. The right coil pack and the left coil pack fire in synch so right and left spark plugs fire together. The coils within a coil pack always fire alternately. For example, in the right coil pack, coil 2 fires, then coil 1 fires, then coil 2 and so on. SPOUT tells DIS precisely when to energize the coils.

EEC-IV computes the spark angle and dwell for the ignition system just like it does in 3.8L SC and 3.0L SHO engines. EEC-IV uses PIP to establish base timing and timing output called SPOUT.

The operation of the ignition diagnostic monitor (IDM) and failure mode effects management (FMEM) for the 2.3L DP is basically the same as the 3.8L SC and 3.0L SHO.

REMEMBER THE FOLLOWING:

- 2.3L DP engine start-up.
  - DPI signal is 12 volts, system in single plug mode and only right coil pack operates
  - no CID is sent to EEC-IV module
  - DIS looks for a CID transition
  - the next trailing edge of SPOUT turns coil 2 primary ON
  - the next leading edge of SPOUT fires coil 2
  - DIS fires the coils in sequence using SPOUT
  - SPOUT is 10° BTDC which is base timing
- Engine running.
  - DPI signal is zero volts, system operates in dual plug mode so right and left coil packs fire in synch
  - no CID is sent to EEC-IV module
  - EEC-IV fires the fuel injectors in pairs
  - CCD provides optimum spark output for various engine operating conditions

IDM

SPOUT tells DIS when to turn a coil ON and when to turn that coil OFF. The ignition diagnostic monitor (IDM) signal mimics SPOUT. The IDM signal is an output from the DIS module that tells EEC-IV that a coil fired (Figure 4-18).

IDM provides diagnostic information about the ignition system for EEC-IV Self-Test. EEC-IV receives the IDM signal and compares it to the signal received from the PIP sensor. If for some reason the IDM signal is interrupted, a continuous code is registered in the EEC-IV memory. The code indicates that during recent engine operation the EEC-IV module received a PIP signal without receiving corresponding IDM input.

IDM is also used to drive the vehicle tachometer. In addition, the IDM signal on 2.3L DP engines tells the EEC-IV module if DPI is in single or dual plug mode. When the engine is operating in the dual plug mode, the IDM signal matches SPOUT. However, when the DPI signal is 12 volts, the engine operates in the single plug mode and the IDM signal is inverted. That is, when SPOUT is high, IDM is low, and when SPOUT is low, IDM is high (Figure 4-19).

FMEM

In case of certain EEC-IV system or particular ignition system failures, the failure mode effects management (FMEM) strategy provides limited vehicle operation.

What if the CID circuit or sensor fails? FMEM allows the engine to be started and the vehicle driven until repairs can be made. As mentioned earlier, during engine crank DIS looks for a CID transition and then prepares to fire coil 2. If the CID signal to the DIS module opens, FMEM causes the DIS module to randomly select a coil to fire.

For example, when an attempt is made to start a 3.8L SC engine, the DIS module will randomly select one of the three coils to energize. Keep in mind, that the coils within the coil pack always fire in a specific sequence. So if DIS begins the sequence by selecting coil 3, coil 1 will fire next, then coil 2, then coil 3 and so on. Furthermore, if coil 3 fires first and neither piston 2 nor 6 is on compression, the spark will not result in that unique combustion event. Cranking will be irregular and the engine will not start.

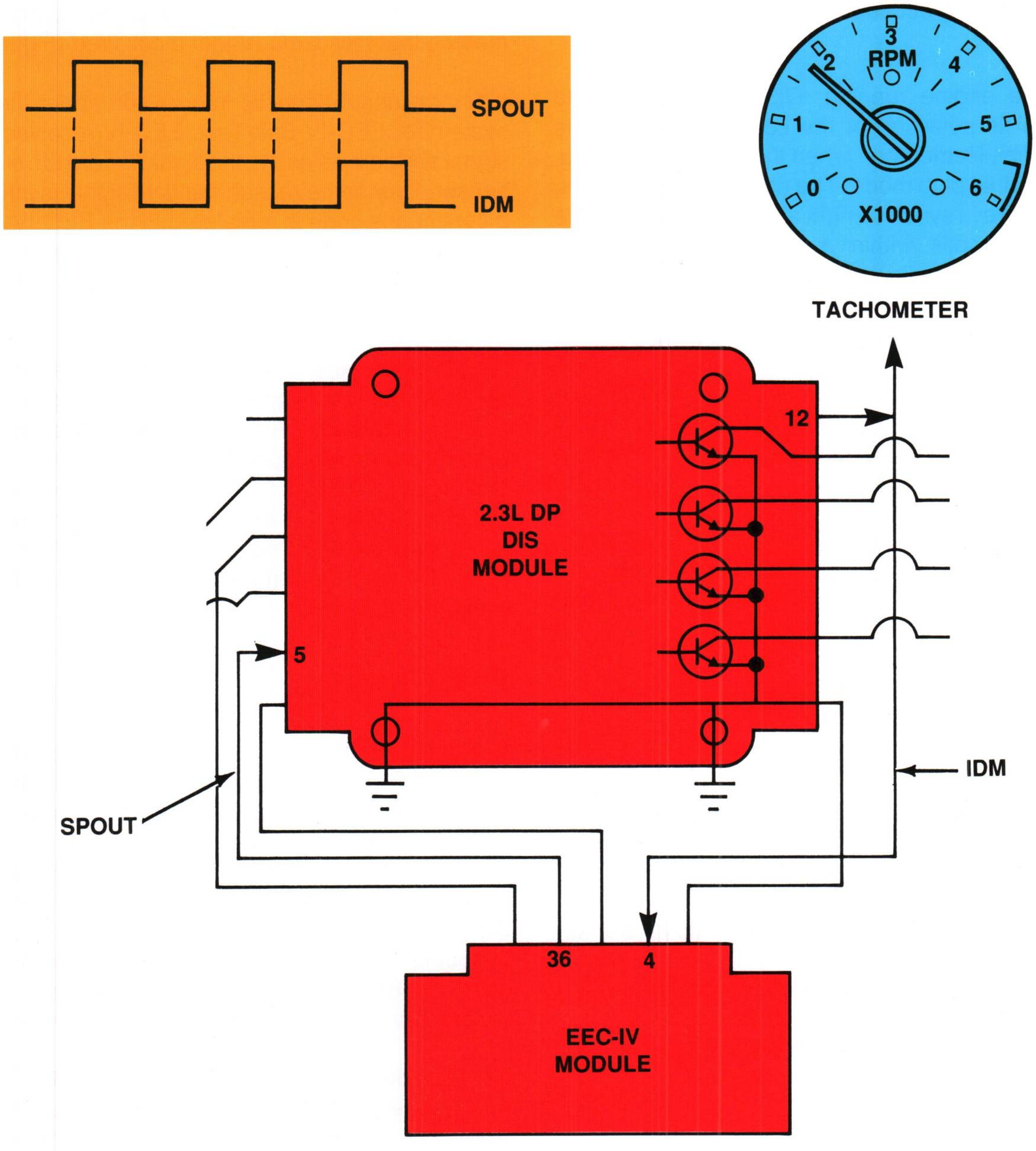


Figure 4-18. IDM Mimics SPOUT and Drives Tachometer - 2.3L DP, Dual Plug Mode Shown

DIS OPERATION

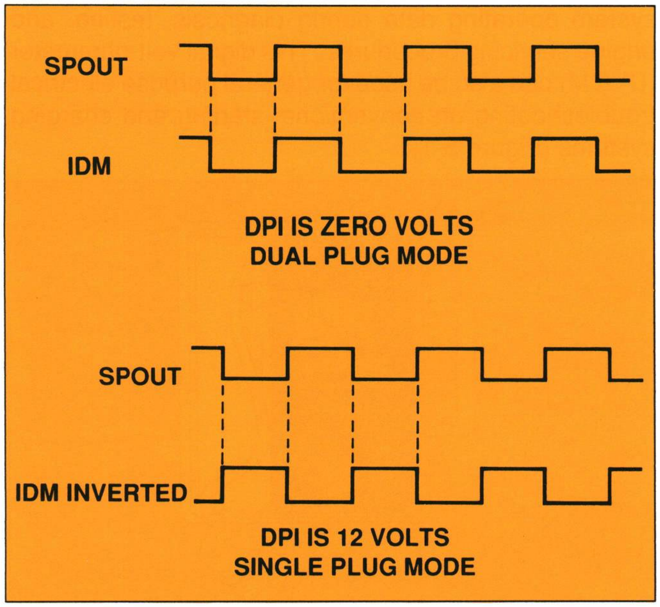


Figure 4-19. SPOUT, IDM and DPI Signals - 2.3L DP

Turn the key OFF. Now try to start the engine again. The DIS module will guess again and may select coil 2. Several attempts may be needed before the proper coil is selected which results in a combustion event and the engine starts. Usually three or four attempts will start the engine.

FMEM also attempts to keep the vehicle driveable in spite of certain EEC-IV system failures. For example, sensor failures that prevent the EEC-IV module from providing spark angle or dwell commands.

In this case, EEC-IV opens the SPOUT line which causes the DIS module to fire the coils directly from PIP. DIS uses the leading edge of PIP to turn a coil OFF and the trailing edge to turn the next coil primary ON. FMEM operation results in a fixed spark angle of 10° BTDC and a fixed dwell. The vehicle may not run well but it will allow the driver to get the vehicle to a dealership for service.

REMEMBER THE FOLLOWING:

- IDM tells EEC-IV that the coils fired and thus provides diagnostic information.
- when 2.3L DP engine is in single plug mode, the IDM signal is inverted.
- IDM drives the vehicle tachometer.
- FMEM provides for limited vehicle operation in case of certain EEC-IV or DIS system failures.

DIAGNOSING AND TESTING DIS

INTRODUCTION

This section lists and describes the equipment required to diagnose DIS. We will also describe suggested equipment that is available for DIS diagnosis. The suggested equipment includes testers that may be used in place of the required diagnostic equipment.

Besides a review of preliminary diagnosis, we will explain how to install the DIS diagnostic equipment and how the equipment operates.

DIS DIAGNOSTIC EQUIPMENT

To accurately diagnose DIS, certain diagnostic equipment and tools are required. In addition, the suggested diagnostic equipment may make the job easier and more convenient.

Prior to diagnosing DIS, obtain the following test equipment equivalent.

REQUIRED

DIS DIAGNOSTIC HARNESS (ROTUNDA 007-00044 OR EQUIVALENT)

This special harness assembly is required to adapt the EEC-IV breakout box (BOB) or EEC-IV monitor to DIS. The harness contains the TEE's required to connect the DIS module, coil packs, PIP sensor, and CID sensor to the EEC-IV breakout box. The multiple pin connector TEE'S are color coded and labeled for easy identification. Included with the cable are EEC-IV breakout box overlays, with color coded wiring schematics, for the 3.8L SC, 3.0L SHO and 2.3L DP engines (Figures 5-6, 5-7, 5-8, 5-11, 5-12 and 5-13).

SPARK TESTER, NEON BULB TYPE (CHAMPION CT-436 OR EQUIVALENT)

There is no need to disconnect a plug wire; just place this spark tester on a spark plug wire to determine if spark is being provided to the plug. This is especially useful for those hard to reach plug wires.

SPARK TESTER, GAP TYPE (SPECIAL SERVICE TOOL D81P-6666-A OR EQUIVALENT)

Connect this gap type spark tester between any spark plug wire and engine ground to instantly determine if spark is being provided to the plug. A spark plug with a broken side electrode is not sufficient to check for spark and may lead to incorrect results.

VOLT-OHMMETER (ROTUNDA 014-00407 OR EQUIVALENT)

A volt-ohmmeter is essential for gathering EEC-IV system operating data during diagnosis, testing, and engine servicing procedures. This digital volt-ohmmeter (DVOM) can also be used for general purpose electrical troubleshooting on conventional starting and charging systems (Figure 5-1).

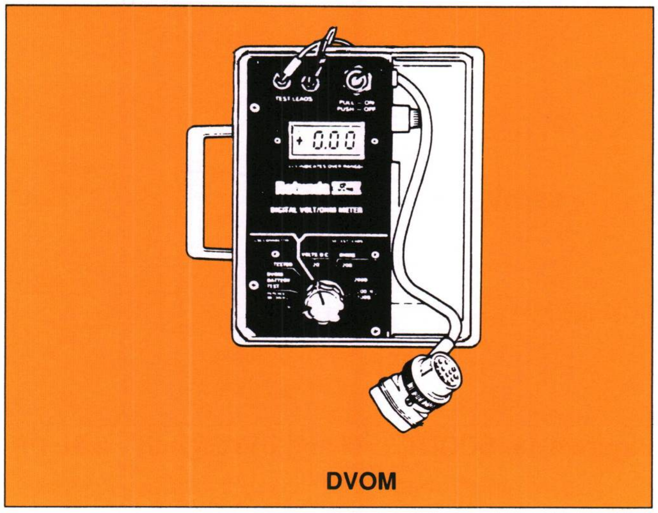


Figure 5-1. Volt-Ohmmeter

12-14 VOLT TEST LAMP

TIMING LIGHT (ROTUNDA 059-00006 OR EQUIVALENT)

This timing light uses an inductive pickup for convenience and safety on 12 volt systems. This timing light includes a tachometer which reads from zero to 3000 RPM (Figure 5-2).

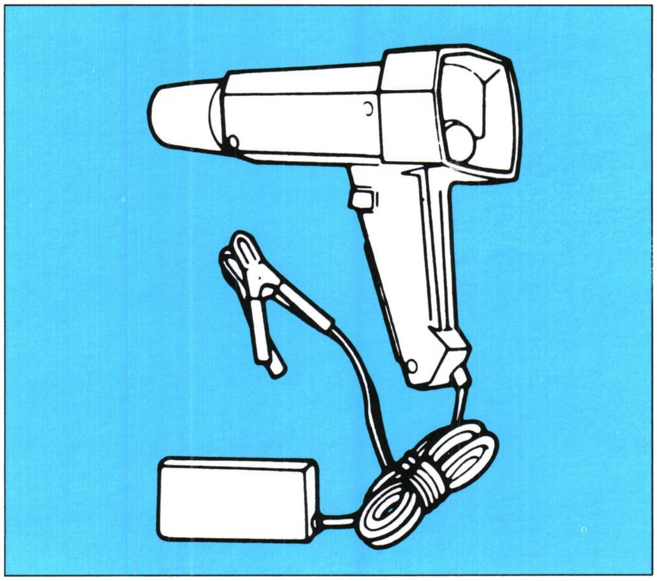


Figure 5-2. Timing Light

SUPER STAR II TESTER (ROTUNDA 007-00041 OR EQUIVALENT)

This tester is used during the key ON engine OFF (KOEO) test to read the codes generated by the EEC-IV system. The built-in memory eliminates the need to watch the display as codes are received (Figure 5-3).

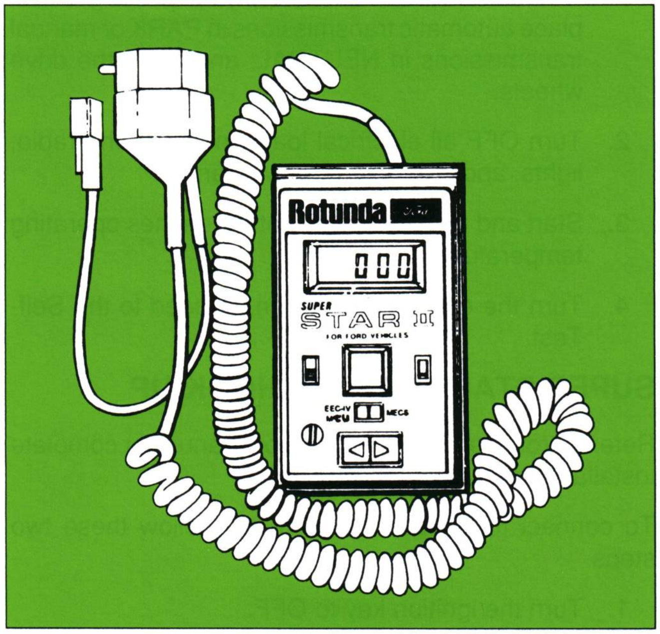


Figure 5-3. Super Star II Tester

EEC-IV 60-PIN BREAKOUT BOX (ROTUNDA T83L-50-EEC-IV OR EQUIVALENT)

This 60-pin breakout box ties into the 60-pin connector provided at the EEC-IV electronic control assembly (ECA). When connected, the information from all 60 electrical circuits of the EEC-IV system is delivered to the remotely located breakout box (Figure 5-4). However, when the DIS diagnostic harness is used with the breakout box, the DIS electrical circuits can be checked.

1989 ENGINE/EMISSIONS-DIAGNOSIS, VOLUME H CAR/TRUCK

SUGGESTED

REMOTE STARTER SWITCH

EEC-IV MONITOR (ROTUNDA 007-00018 OR EQUIVALENT)

As you know, the EEC-IV monitor is a useful tool for diagnosing driveability symptoms caused by the sensors and actuators of the EEC-IV system. In addition, by using the DIS diagnostic harness, the monitor can be adapted to troubleshoot faults which may occur in DIS on the 3.8L SC, 3.0L SHO, and 2.3L DP engines.

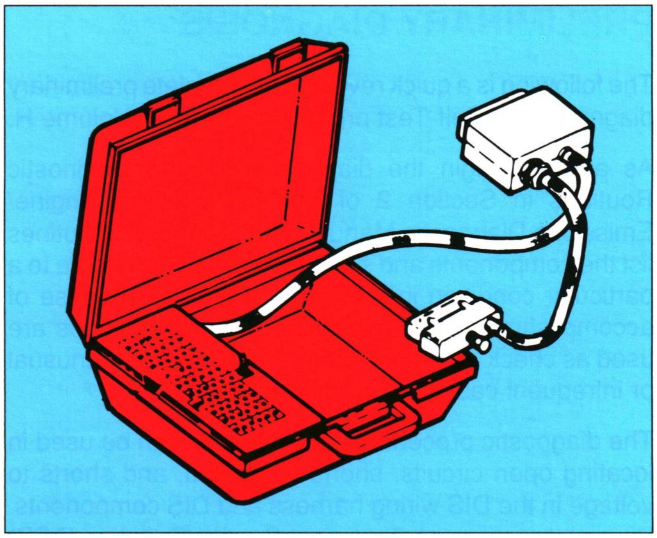


Figure 5-4. EEC-IV Breakout Box

The DIS Diagnostic Harness (Rotunda 007-00044) connects to the DIS system by connecting to the DIS module, coil packs, CID sensor and the PIP sensor. A 60-pin connector attaches to the monitor. With the monitor, the DIS signals can be observed and measured in a key ON engine OFF (KOEO) or key ON engine running (KOER) state.

DIS MODULE TESTER AND DIS COIL/SENSOR TESTER (ROTUNDA 007-00070 OR EQUIVALENT)

The module tester hand-held box contains 12 test jacks, 12 LED's (light emitting diode), and a LAMP TEST button to test the LED's. When the cable TEE's are connected to any DIS module, the tester is used to verify the signals that enter and exit the DIS module. The LED's show the activity of the ignition signals. Also, panel test jacks allow continuity and voltage checks.

The coil/sensor tester is also a hand-held box and is used to verify the signals that enter and exit the DIS coils or sensors. The LED's show the activity of the ignition signals for the 3.8L SC, 3.0L SHO, and 2.3L DP engines. This tester contains 15 test jacks, 15 LED's and a LAMP TEST button to test the LED's. Cables with the necessary TEE's are used to connect to coils, PIP sensor, and CID sensor. The panel test jacks allow easy access to all DIS connections.

DIAGNOSING AND TESTING DIS

PRELIMINARY DIAGNOSIS

The following is a quick review. For complete preliminary diagnosis and Self-Test procedures, refer to Volume H.

As always, begin the diagnosis with the Diagnostic Routines in Section 2 of Volume H, 1989 Engine/ Emissions Diagnostic Manual. The Diagnostic Routines list the components and systems that can contribute to a particular condition in the order of probability, ease of accomplishment, and accessibility. These routines are used as check lists for reference in the event of unusual or infrequent causes of a malfunction.

The diagnostic procedures in Volume H can be used in locating open circuits, shorts to ground, and shorts to voltage in the DIS wiring harness and DIS components. Be sure to review all Technical Service Bulletins (TSB) for possible revisions to the Volume H procedures.

Remember, the best way, the only way to diagnose modern engine problems is to be systematic. Follow good information gathering procedures. Let your experience and hunches guide you up to a point, but then turn to the best guide of all, Volume H, if you have any doubts or find yourself stuck.

VISUAL CHECK

Keep in mind, correct results of the Self-Test depend on the proper operation of related, non-EEC-IV components. The following visual checks must be performed prior to running the Self-Test.

1. Inspect the air cleaner and inlet ducting for obstructions and proper installation.
2. Check all the engine vacuum hoses for correct routing and clean, tight connections at the fittings. Listen for leaks and look for damaged hoses or fittings. Check that hoses are not pinched or blocked.
3. Carefully inspect the wiring harnesses of the electrical and electronic systems. Look for proper connections and loose or detached connectors, wires or terminals. Check for corrosion, frayed wires, bent or broken pins and other damage.
4. Check the EEC-IV module, the sensors and the actuators for physical damage.
5. Check the coolant level for proper level and concentration.
6. Check the transmission fluid level and quality.
7. Make all necessary repairs before continuing with the Self-Test.

VEHICLE PREPARATION FOR SELF-TEST

1. Perform all the safety steps required to start and run vehicle tests. That is, apply the parking brake, place automatic transmissions in PARK or manual transmissions in NEUTRAL, and block the drive wheels.
2. Turn OFF all electrical loads including the radio, lights, and A/C-heater blower fans.
3. Start and run the engine until it reaches operating temperature.
4. Turn the engine OFF. Then proceed to the Self-Test.

SUPER STAR II TESTER HOOK-UP

Refer to Volume H or the instruction manual for complete installation and use of this tester.

To connect the Super Star II tester, follow these two steps.

1. Turn the ignition key to OFF.
2. Connect the two Self-Test service connectors to the matching connectors under the vehicle hood. There is a 3-pin connector and a single-pin connector (Figure 5-5).

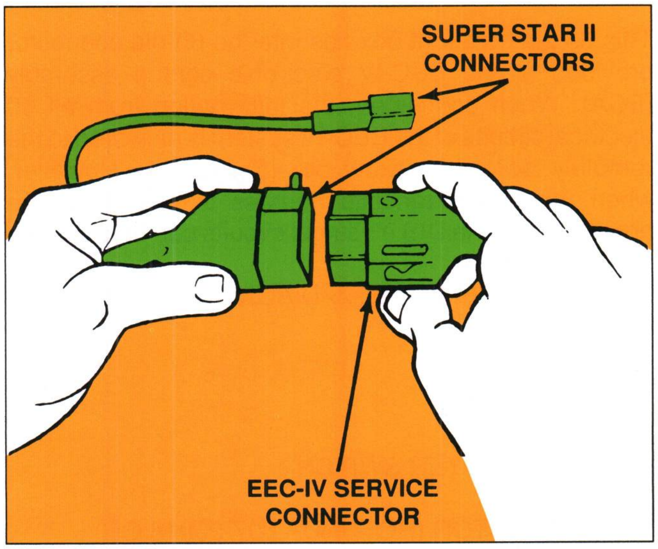


Figure 5-5. Super Star II Connection

KEY ON, ENGINE OFF (KOEO) SELF-TEST

After completing the visual check, preparing the vehicle, and connecting the Super Star II tester, we can perform the Self-Test to check for service codes. Service codes stored in the memory of the EEC-IV module indicate faults detected during engine operation. The six types of service codes are explained in the Star Tester Instruction Manual and in Volume H. The built-in memory of the Super Star II eliminates the need to write down the codes as they are received.

The following is a brief description of the KOEO Self-Test procedure using the Super Star II tester. The complete procedure is described in the instruction manual supplied with the tester.

1. With the tester connected, set the EEC-IV-MCU/MECS switch to EEC-IV-MCU.
2. Use the MODE switch to select SLOW or FAST code mode.
3. Turn the power switch to PWR.
4. Turn the ignition key to the ON position.
5. Depress the HOLD/TEST button to the TEST position. The STI LO prompt should appear in the readout.
6. Receive and read the service codes.
7. Interpret the service code output as follows:
    - if the first code to appear in the readout is the numeral 11, there are no hard faults. Any other code indicates a hard fault, therefore, follow the "ACTION TO TAKE" instructions in Section 14 of Volume H.
    - a separator Code 10 appears in the readout to indicate the EEC-IV module is checking for continuous memory codes.
    - if the first code following the separator Code 10 is the numeral 11, there are no continuous memory codes. Any other code displayed in the readout at this time indicates a continuous memory code stored in the memory of the EEC-IV module. Follow the "ACTION TO TAKE" instructions in Volume H for the code(s) indicated.

IGNITION SYSTEM PINPOINT TESTS

Many times a continuous memory code directs you to a pinpoint test as the "ACTION TO TAKE." The pinpoint test of Section 17 may, in turn, "REFER" you to a particular section of Volume H.

When performing pinpoint test and the test steps in other Volume H sections, keep the following notes in mind:

- spark plug timing adjustments cannot be made on DIS.
- when making measurements on a wiring harness, both a visual inspection and a continuity test should be performed.
- when making voltage checks, a ground reading means any value within a range of zero to 1 volt. Also, VBAT means any value that falls within a range from battery voltage to 2 volts less than battery voltage.
- when making voltage checks and a reference to ground is made, use either the negative lead at the battery, or cast iron on the engine, unless directed to use the negative terminal of the battery.
- if ground is disconnected, turn the ignition key to OFF before reconnecting ground.
- ignition ground (IGND) is a low current reference for the DIS module and the EEC-IV module. IGND is connected to battery negative (ground) via the DIS module metal base plate. Proper system operation depends on this resistance path. Check that the DIS module is securely fastened. The base plate must make solid contact with the engine. All mounting screws must be installed and tightened to specification.
- when using the neon spark plug firing indicator, place the grooved end as close as possible to the plug boot. A fouled plug may cause weak flashing.
- the spark plugs are wired in series in the DIS secondary circuit. Each coil within a coil pack supplies energy to two plugs, therefore, one plug fires from positive to negative while the other plug fires from negative to positive. Therefore, the engine analyzer will indicate negative firing voltage results if the analyzer is not set up for DIS.
- do not ground the coils because the coil pack will be destroyed.

USING DIS DIAGNOSTIC EQUIPMENT

Now let's see how to install and use the equipment needed to diagnose DIS. Since you are familiar with the EEC-IV breakout box, the Super Star II tester, timing light, volt-ohmmeter, and test lamp, we will concentrate on the equipment designed specifically for DIS; that is, the DIS diagnostic harness as used with the EEC-IV breakout box and the EEC-IV monitor, the DIS module tester, and the DIS coil/sensor tester.

Remember, after a DIS fault has been located and repaired, verify the problem has been solved. This may require a road test to verify that the symptom is no longer present. If any Quick Test Codes were present before the fault was repaired, then those codes must be cleared as described in Volume H.

As in all diagnostic and service procedures, think safety first, for example:

- be sure the ignition switch is OFF or the cooling fan electrical connector is disconnected if the key must be ON; the cooling fan may start at any time.
- set the parking brake.
- set automatic transmissions in PARK or manual transmissions in REVERSE.
- place wood blocks against the front and rear surfaces of the tires to provide further restraint from inadvertent vehicle movement.
- route the diagnostic harness away from drive belts or any other moving parts of the engine.

Now let's take a closer look at this diagnostic equipment.

DIS DIAGNOSTIC HARNESS

At first glance, the DIS diagnostic harness looks like it will be a real challenge to use (Figure 5-6). However, it takes but a few minutes to install the harness and results in fast, accurate, convenient diagnosis of the distributorless ignition system. Once the TEE's of the harness are interconnected to the engine wiring harness, the 60-pin connector easily attaches to the EEC-IV breakout box or the EEC-IV monitor. Now you can check every component, wire, and harness of DIS.

This diagnostic harness can be used on the 3.8L SC, 3.0L SHO and 2.3L DP engines. The harness has seven TEE's. Only five of the TEE's are needed to connect the DIS harness of an engine to the EEC-IV breakout box or the EEC-IV monitor.

Of course, when connected, the diagnostic harness only monitors DIS. That is, you can't use the breakout box to check the EEC-IV system and DIS at the same time. The

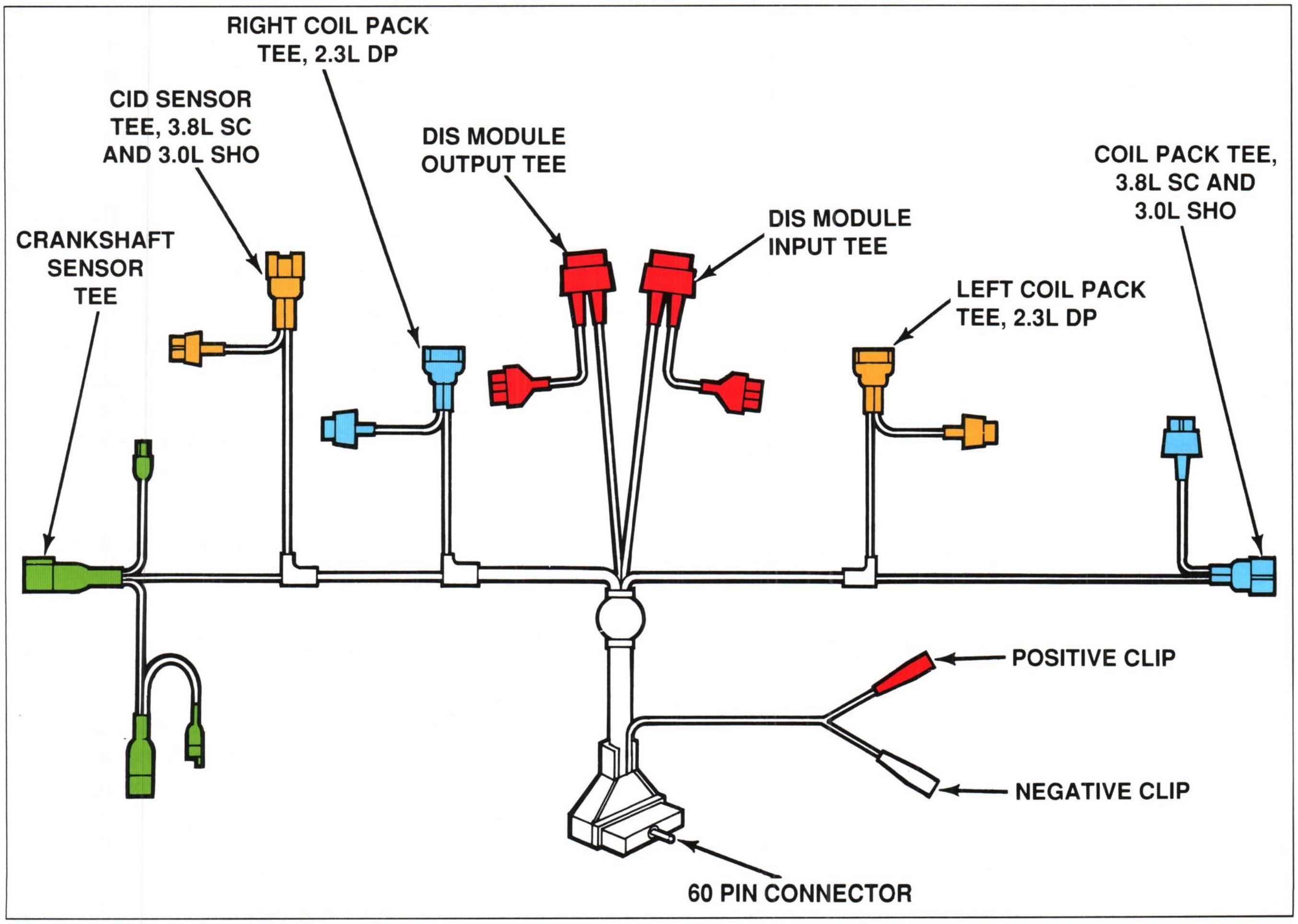

RIGHT COIL PACK TEE, 2.3L DP
CID SENSOR TEE, 3.8L SC AND 3.0L SHO
DIS MODULE OUTPUT TEE
COIL PACK TEE, 3.8L SC AND 3.0L SHO
DIS MODULE INPUT TEE
CRANKSHAFT SENSOR TEE
LEFT COIL PACK TEE, 2.3L DP
POSITIVE CLIP
NEGATIVE CLIP
60 PIN CONNECTOR

Figure 5-6. DIS Diagnostic Harness

same is true when the EEC-IV monitor is connected to the DIS diagnostic harness; only DIS can be checked.

Installation

To install the DIS diagnostic harness to the engine wiring harness, follow these steps.

1. Turn the ignition switch OFF before connecting or disconnecting any engine harness connectors or any diagnostic harness connectors. Inspect all connectors for loose pins, damaged pins, corrosion, or loose wires.
2. Route the harness away from spark plug wires, moving parts of the engine, hot engine components, or other obstructions. Safe placement of the harness will avoid damage from interference during engine operation. Wire ties can be used to attach the cables of the DIS diagnostic harness to fixed engine locations. Specifically, the cable of the CID sensor on the 3.8L SC must be secured away from the drive belts.
3. Disconnect the engine wiring harness from a DIS component. Connect one end of a diagnostic harness TEE to the DIS component. Then connect the other end of the TEE to the engine wiring harness. Be sure the connections are secure. Some connectors lock in place.

   For easy identification, each TEE of the diagnostic harness has a color coded label. The wiring schematic supplied with the harness is color coded to match the harness and also matches the overlay for the EEC-IV BOB (Figures 5-6, 5-7, 5-8, 5-11, 5-12 and 5-13).
4. Connect the 60-pin connector of the diagnostic harness to the EEC-IV breakout box or EEC-IV

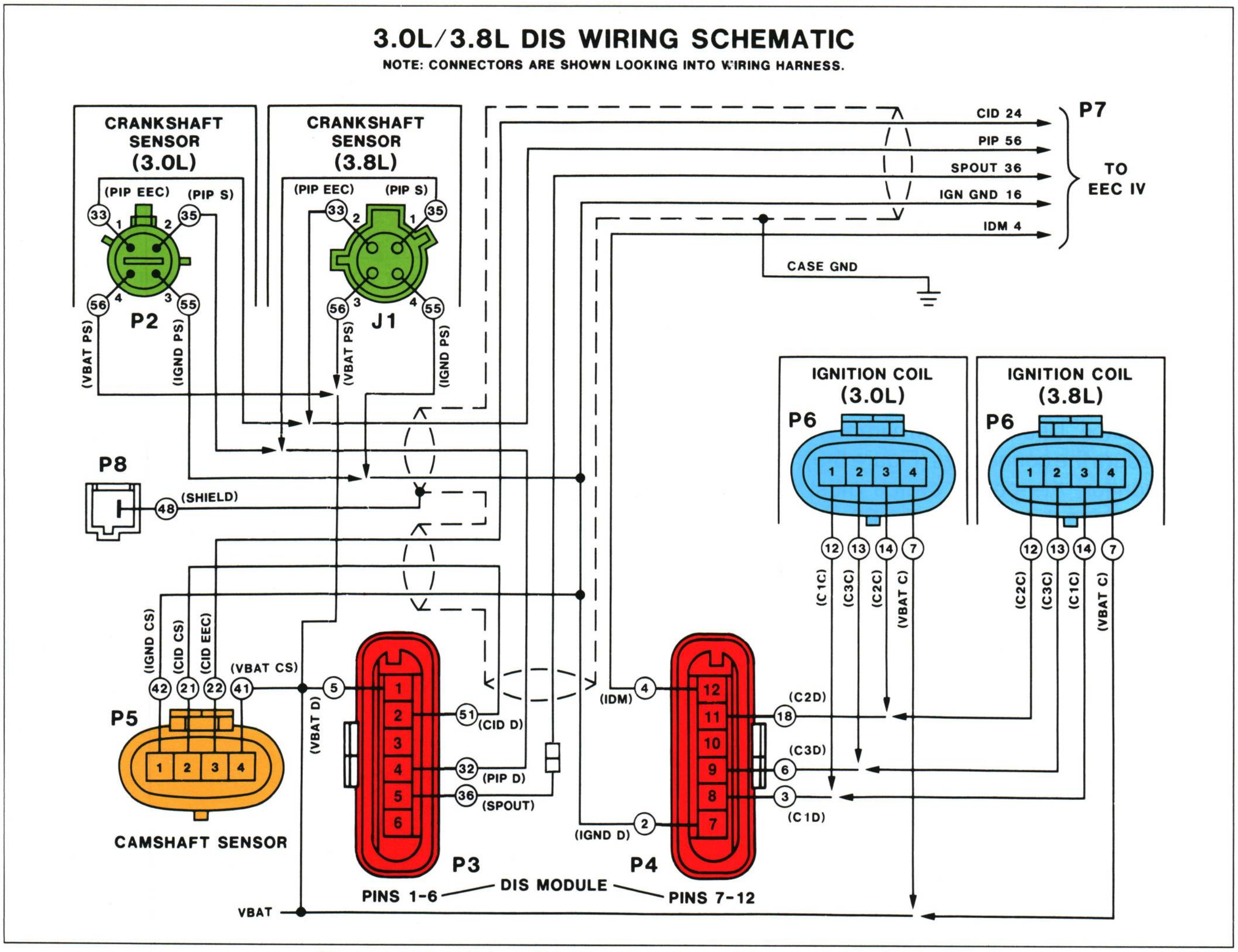


Figure 5-7. Wiring Schematic - 3.8L SC and 3.0L SHO

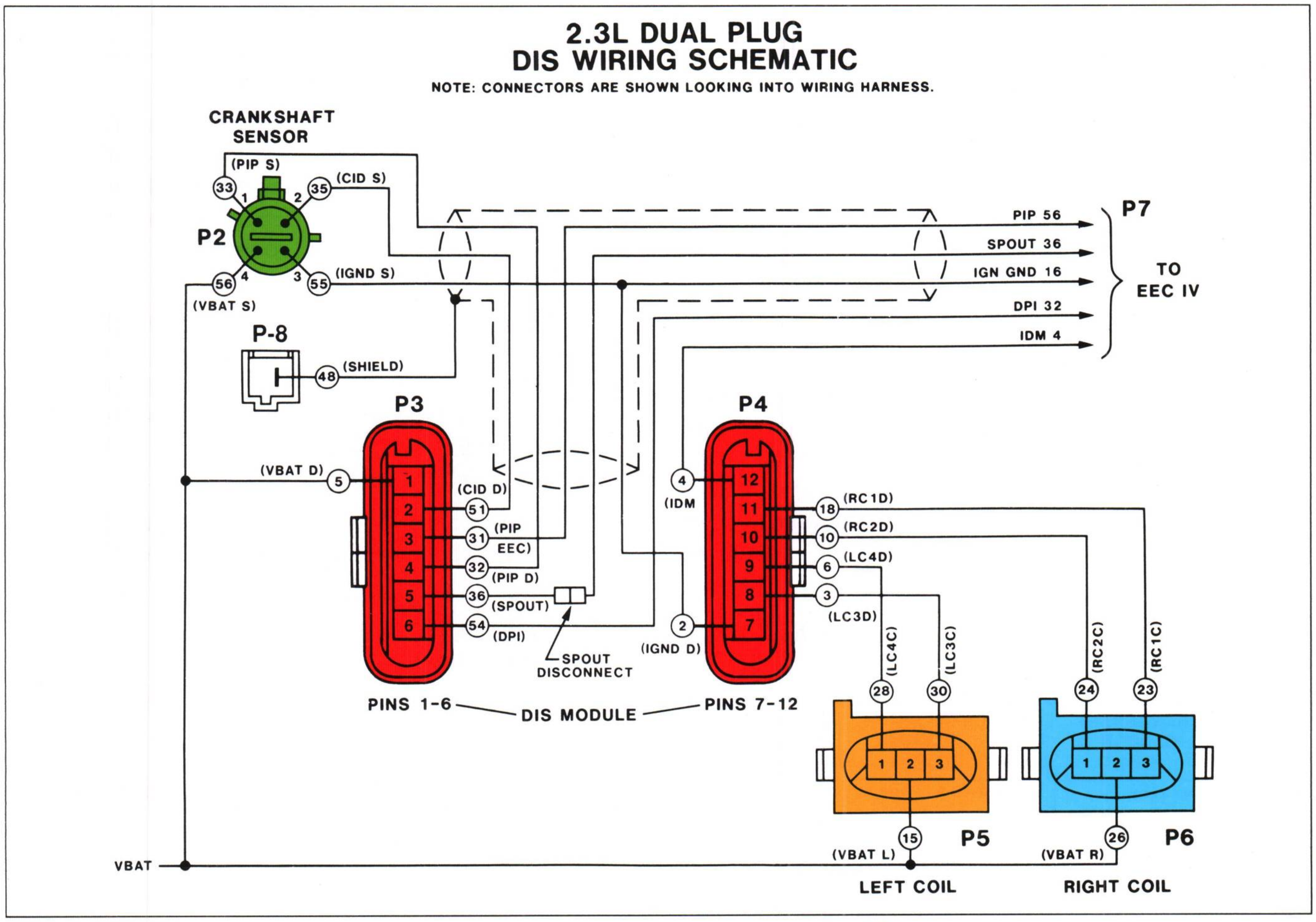


Figure 5-8. Wiring Schematic - 2.3L DP

monitor. Use a 10 mm wrench or nut driver to secure the connectors (Figure 5-9). On the EEC-IV monitor, the power switch must be OFF when attaching the DIS harness 60-pin connector.

5. Now attach the red clip to the positive terminal of the battery and attach the black clip to the negative terminal of the battery.

   Make sure power connections are secure before turning the ignition key ON. Attaching the ground wire after the key is ON may cause a coil to fire and the engine to turn over.

6. Position the correct engine overlay on the EEC-IV breakout box (Figure 5-10) or EEC-IV monitor.

7. Refer to the color coded wiring schematic for the engine being diagnosed (Figures 5-7 and 5-8).

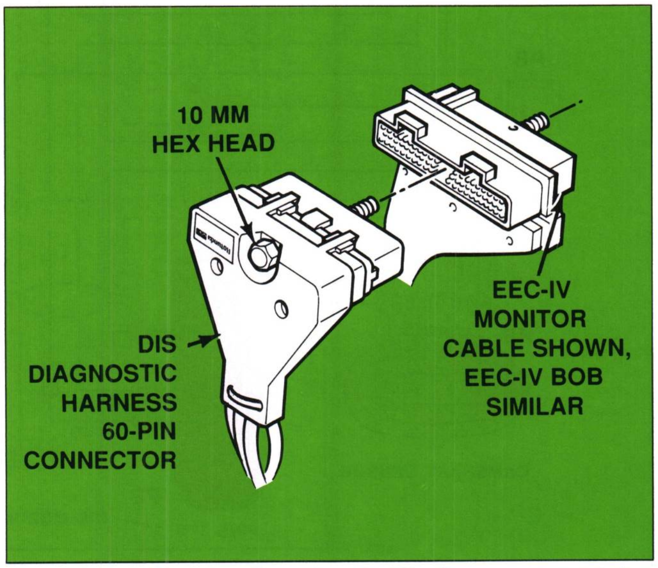


Figure 5-9. Connecting the 60-Pin Connector of the DIS Diagnostic Harness

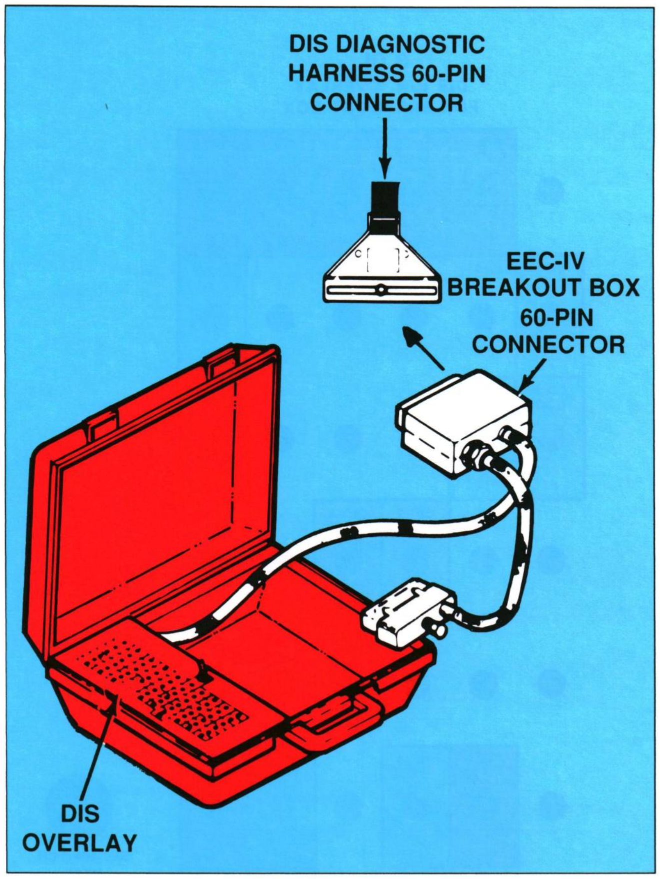

DIS DIAGNOSTIC HARNESS 60-PIN CONNECTOR
EEC-IV BREAKOUT BOX 60-PIN CONNECTOR
DIS OVERLAY

Figure 5-10. Install Correct Engine Overlay

Color Coded TEE's

The DIS diagnostic harness connectors, the engine overlays, and the wiring schematics are color coded.

For example, red indicates the input and the output of the DIS module. The TEE's of the diagnostic harness are labeled with MODULE in red. The module harness connections on the wiring schematics are red. The overlay for the EEC-IV breakout box is colored red for all the panel jacks used to test input or output of the DIS module.

The following notes explain the color codes and detail the harness TEE's used to properly connect the diagnostic harness to each of the DIS engines.

When installing the diagnostic harness, note that:

- two of the TEE's are used only with the 3.8L SC and 3.0L SHO engines; the yellow SENSOR TEE and one of the blue COIL TEE's.
- two of the TEE's are used only for the 2.3L DP coil packs; the yellow COIL TEE and one of the blue COIL TEE's.
- the green SENSOR TEE includes a shield connector and this TEE is used for all DIS engines.

3.8L SC AND 3.0L SHO TEE's

For 3.8L SC and 3.0L SHO engines, use the following diagnostic harness connectors:

- a blue COIL pack TEE.
- the yellow CID SENSOR TEE.
- the red MODULE TEE for input.
- the red MODULE TEE for output.
- the green PIP SENSOR TEE and the shield connector.

2.3L DP TEE's

For the 2.3L DP engine, use the following diagnostic harness connectors:

- a blue COIL TEE for the right coil pack.
- the yellow COIL TEE for the left coil pack.
- the red MODULE TEE for input.
- the red MODULE TEE for output.
- the green dual Hall SENSOR TEE and the shield connector.

USING THE EEC-IV BREAKOUT BOX

The EEC-IV 60-pin breakout box is used to perform the pinpoint test as noted in Volume H.

You can access all the information from the DIS circuits through the pin jacks on the front panel of the breakout box. Plug the 60-pin connector of the breakout box into the 60-pin connector of the DIS diagnostic harness. Use a DVOM such as Rotunda 014-00407, or equivalent, to make the circuit measurements of DIS as required by the pinpoint test routings. The test leads of a DVOM plug into the panel test jacks of the breakout box to access the circuits of DIS.

Color coded breakout box overlays and wiring schematics are supplied with the DIS diagnostic harness. There is a specific overlay for each DIS engine (Figures 5-11, 5-12 and 5-13). The overlays are used to identify the test jacks, which connect to specific points of the DIS circuit. These test jacks are colored, labeled, and numbered. The colors, labels, and numbers correspond to the colors, labels, and numbers on the wiring schematic.

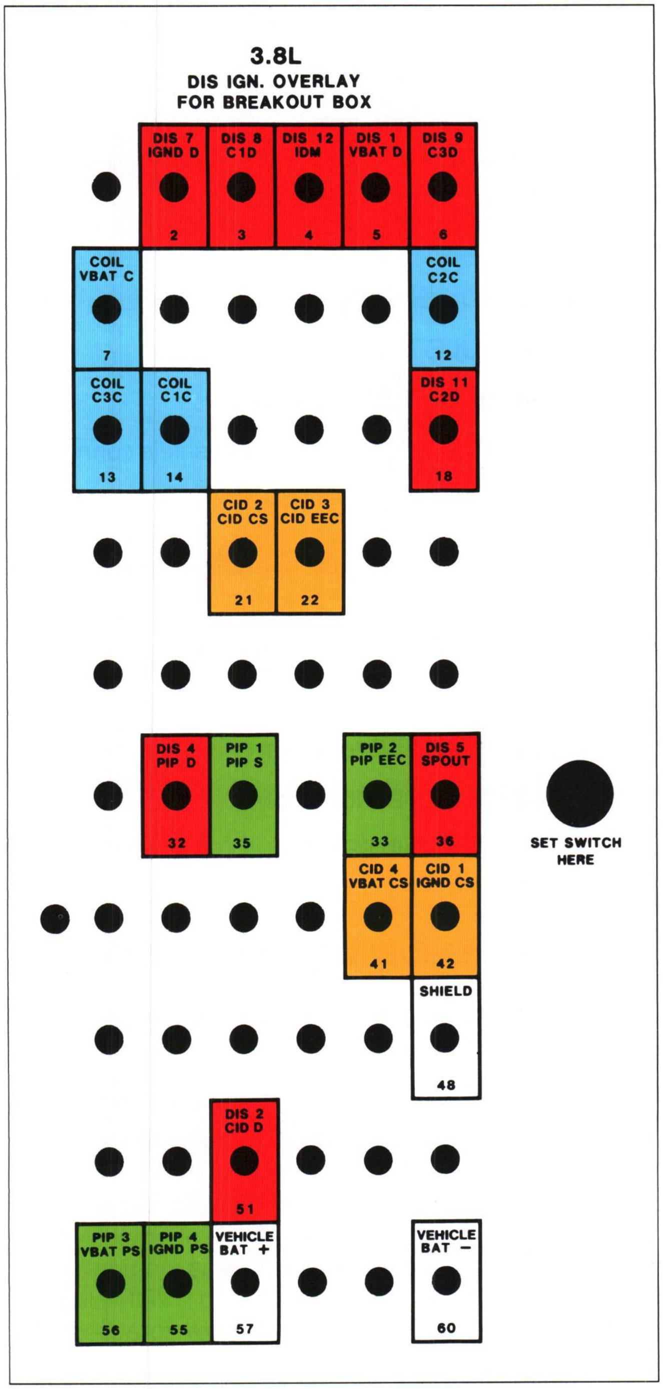


Figure 5-11. 3.8L SC Overlay for EEC-IV Breakout Box

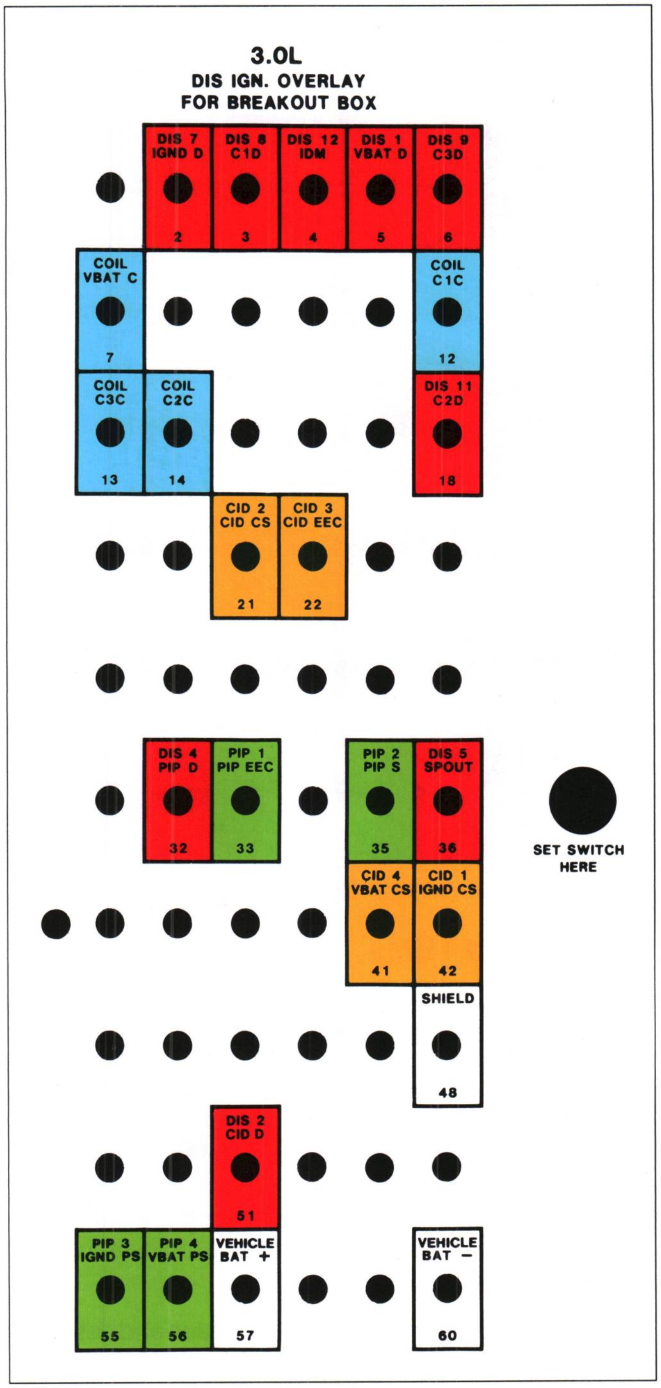


Figure 5-12. 3.0L SHO EEC-IV Breakout Box Overlay

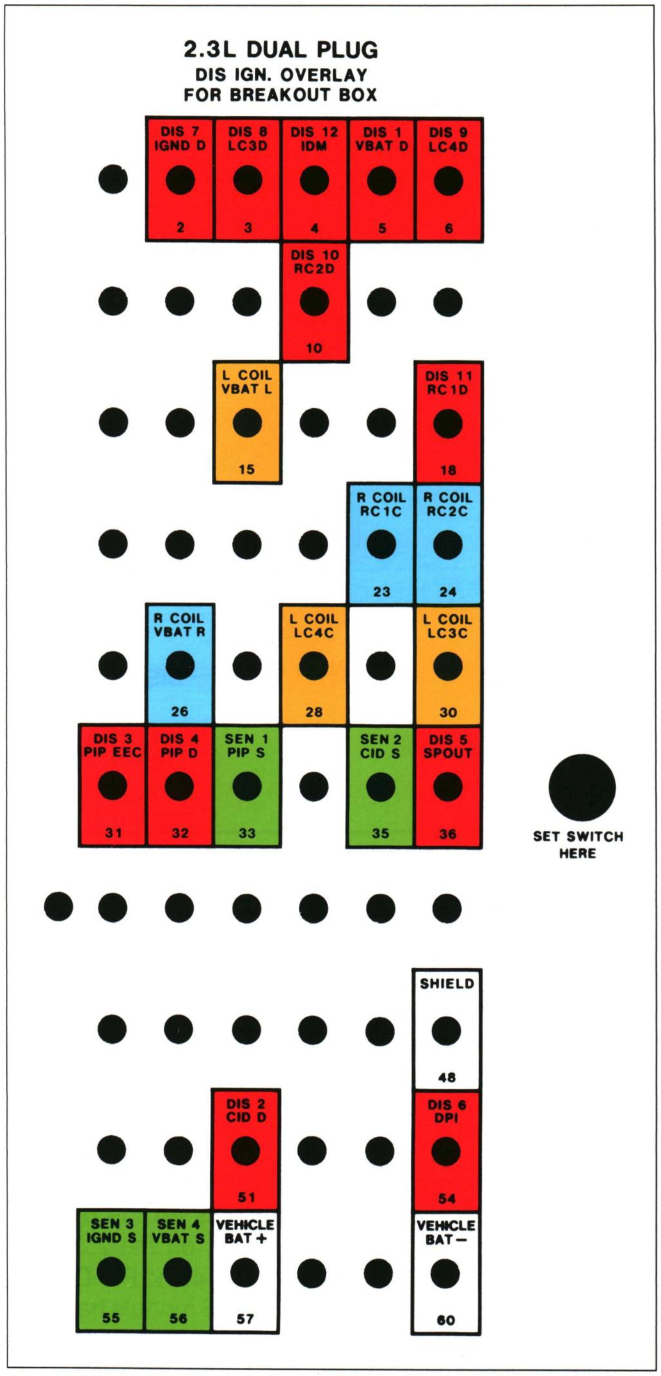


Figure 5-13. 2.3L DP EEC-IV Breakout Box Overlay

These labels, numbers, and colors provide the following information:

- numbers that identify the test jacks are circled on the wiring schematic.
- abbreviated labels are used as callouts to identify the wire name and pinpoint location of the test jack.
- labels with numbers identify the pin number and the name of the harness connector.
- colors identify the harness connectors at specific components.

For example, look at test jack number 35 on the 2.3L DP overlay (Figure 5-14). The jack is green and labeled SEN 2 and CID S. Green denotes a crankshaft sensor harness. SEN 2 means pin 2 of that harness. CID S identifies the CID signal line at the dual Hall sensor.

Now check the 2.3L DP wiring schematic. Connector P2 at the dual Hall sensor is green. Pin 2 at the connector is the pinpoint for test jack 35 as indicated by the circled 35. This pinpoint is the CID signal output at the dual Hall sensor as noted by (CID S).

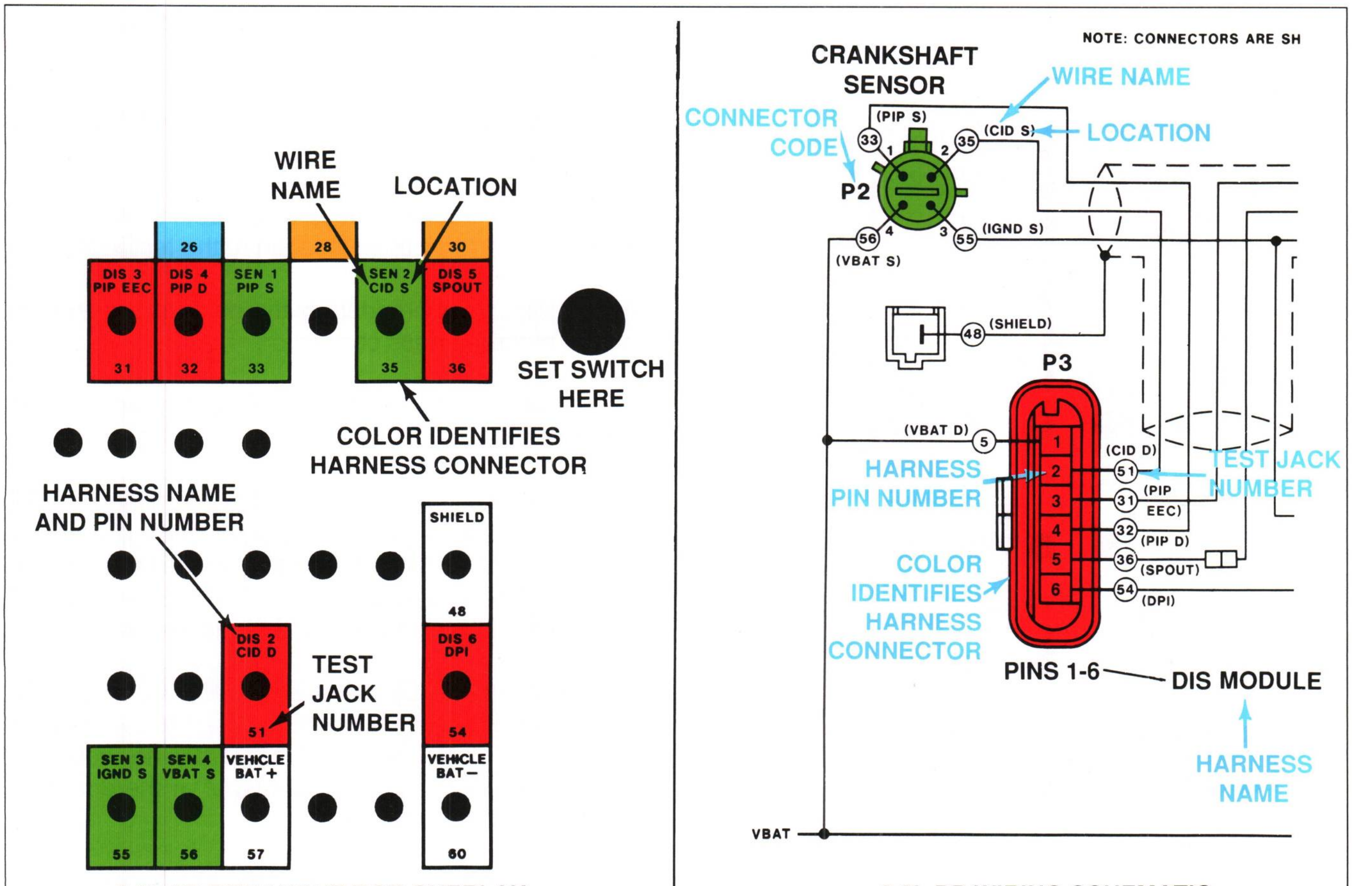
To continue this example, note that breakout box test jack 51 is red and labeled DIS 2 and CID D. On the 2.3L DP schematic, connector P3 at the DIS module is red. Pin 2 is the CID signal line at the DIS module, (CID D), and is the pinpoint for test jack 51.

As you can see, a continuity check of the CID signal line is easy using the EEC-IV breakout box. Using an ohmmeter, plug the test leads into test jacks 35 and 51.

For complete DIS diagnosing and testing procedures using the EEC-IV breakout box, refer to Volume H.

USING THE EEC-IV MONITOR

The following is a brief explanation about using the EEC-IV monitor to diagnose DIS. For detailed information on the monitor and complete DIS diagnostic procedures,



2.3L DP BREAKOUT BOX OVERLAY **2.3L DP WIRING SCHEMATIC**

Figure 5-14. Pinpoints are Labeled, Numbered and Colored

refer to Volume H and the EEC-IV Monitor Instruction Manual.

The EEC-IV monitor is a useful tool for diagnosing DIS. When the 60-pin connector of the EEC-IV monitor is connected to the DIS diagnostic harness, the monitor can be used to troubleshoot faults in DIS. Using the diagnostic harness and the monitor, DIS signals can be observed and measured.

There are several advantages for using the monitor to test DIS:

- the monitor lights, or LED's, give a quick indication of signal status and faults.
- allows you the ability to use the sensitive monitor wiggle testing.
- you can measure certain DIS signals in RPM, percent (%) or duty cycle units, in addition to DC volts measurements.
- allows dynamic testing of DIS at KOER conditions.

As with the EEC-IV breakout box, specific DIS engine overlays are available for the EEC-IV monitor (Figures 5-15, 5-16 and 5-17). These monitor overlays also use labels which correspond to the wiring schematics (Figure 5-18).

Each LED on the monitor is used to observe a particular pinpoint in the DIS circuits. The labels on the overlay identify these pinpoints. For example, on the 2.3L DP overlay, one of the LED's is labeled DIS 4 and PIP D. This means the LED monitors pin 4 at the DIS module harness connector which is PIP input at the module. By watching the LED's and using the "Symptom Analysis Charts" in Volume H, most open circuits and short circuits can be found.

PRELIMINARY CHECKS

Before attaching the 60-pin connector of the DIS diagnostic harness to the EEC-IV monitor, turn the monitor power switch OFF. Be sure the ignition key is OFF.

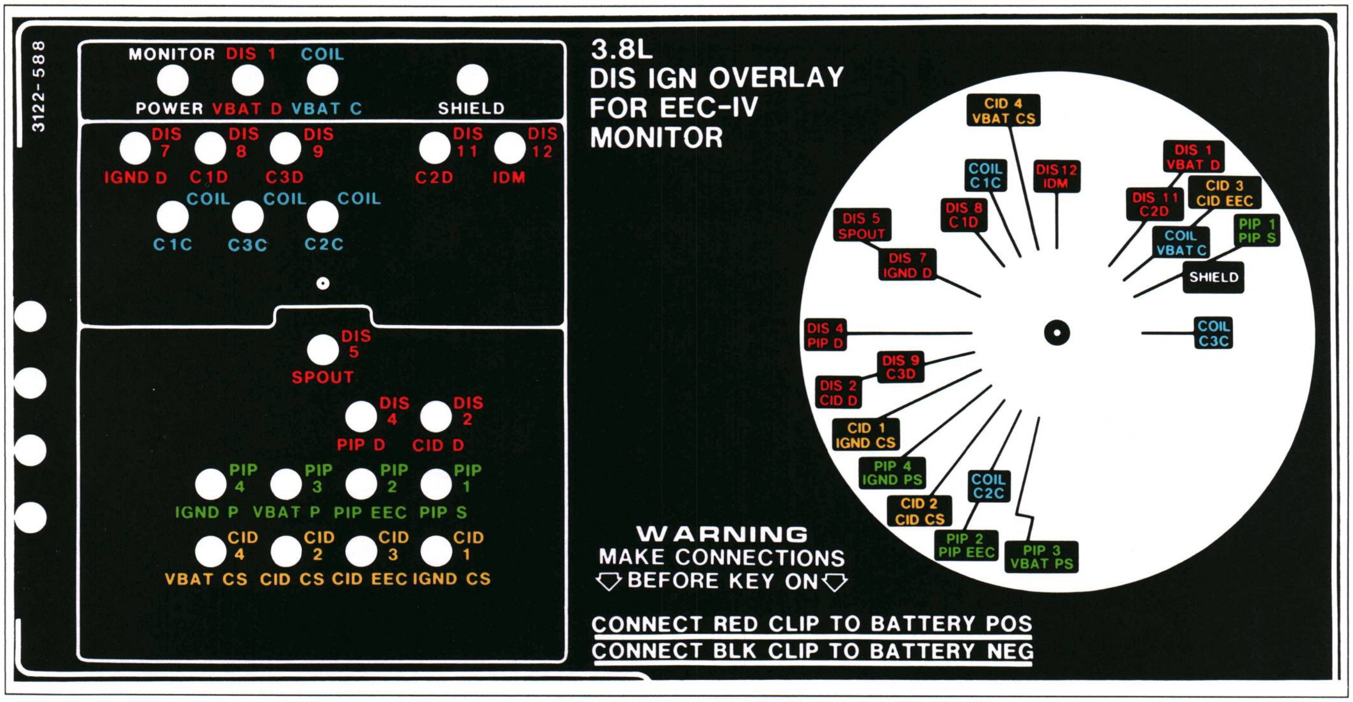


Figure 5-15. 3.8L SC EEC-IV Monitor Overlay

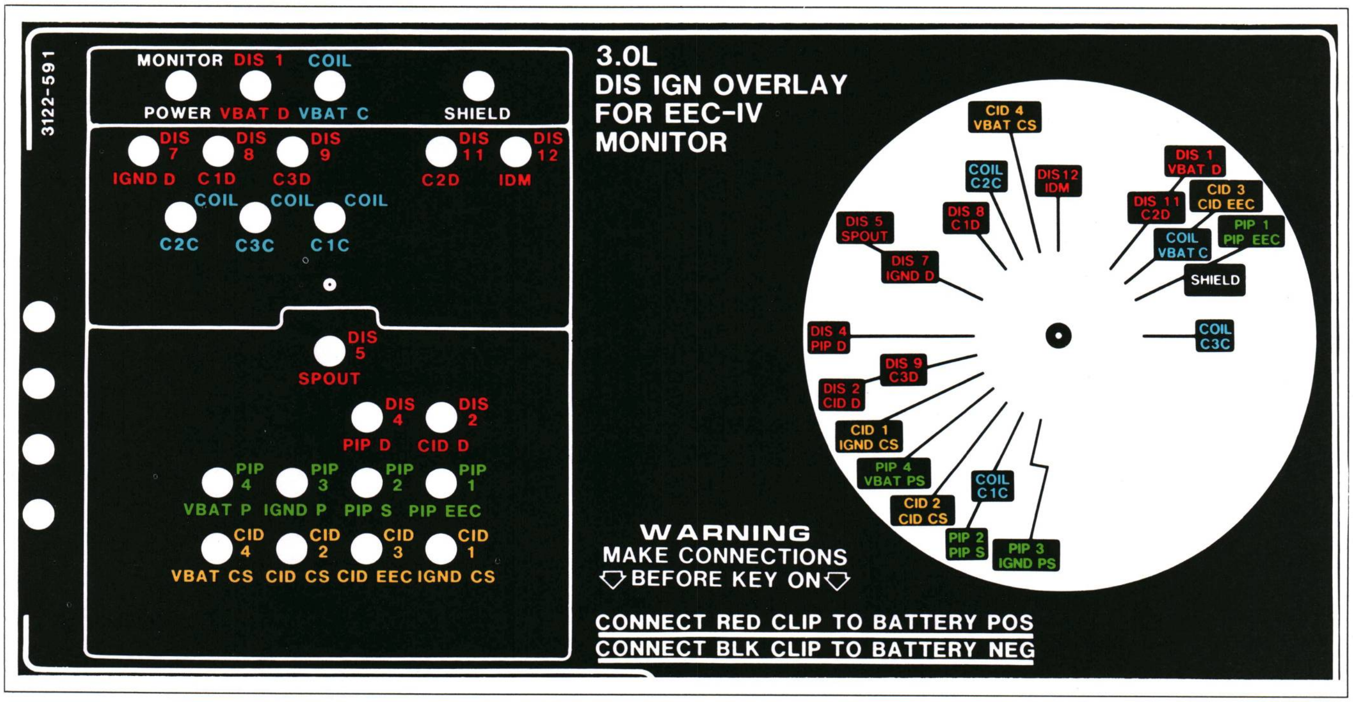


Figure 5-16. 3.0L SHO EEC-IV Monitor Overlay

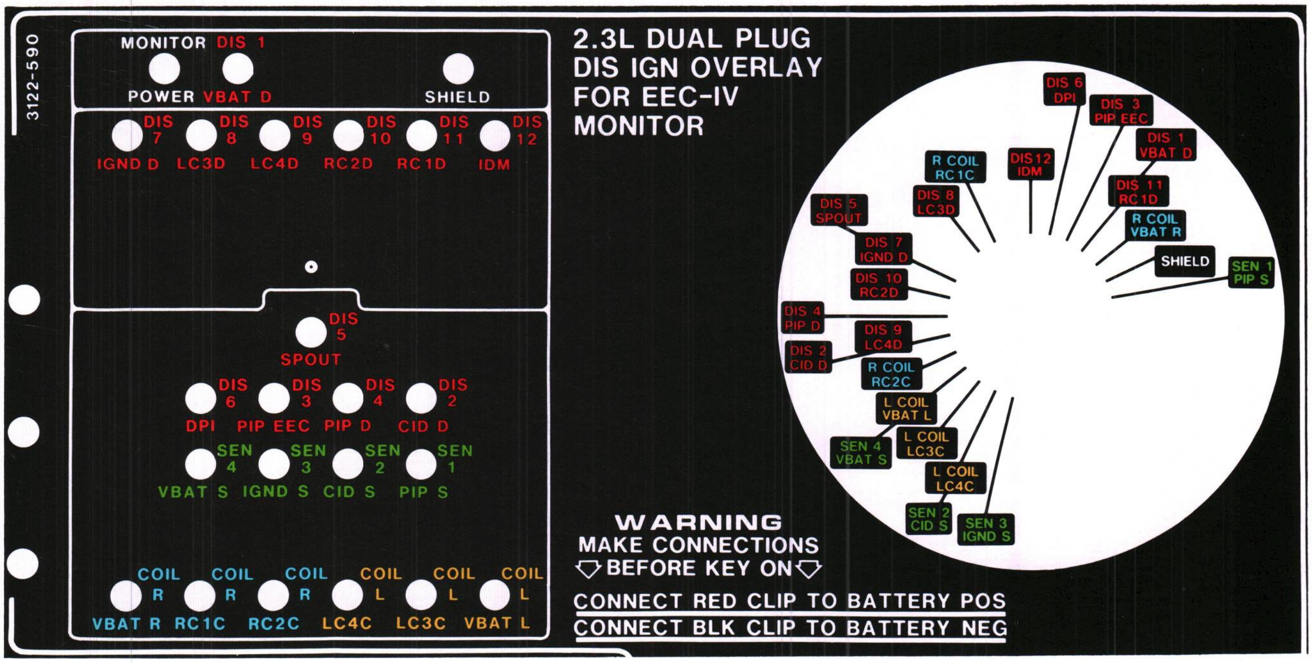
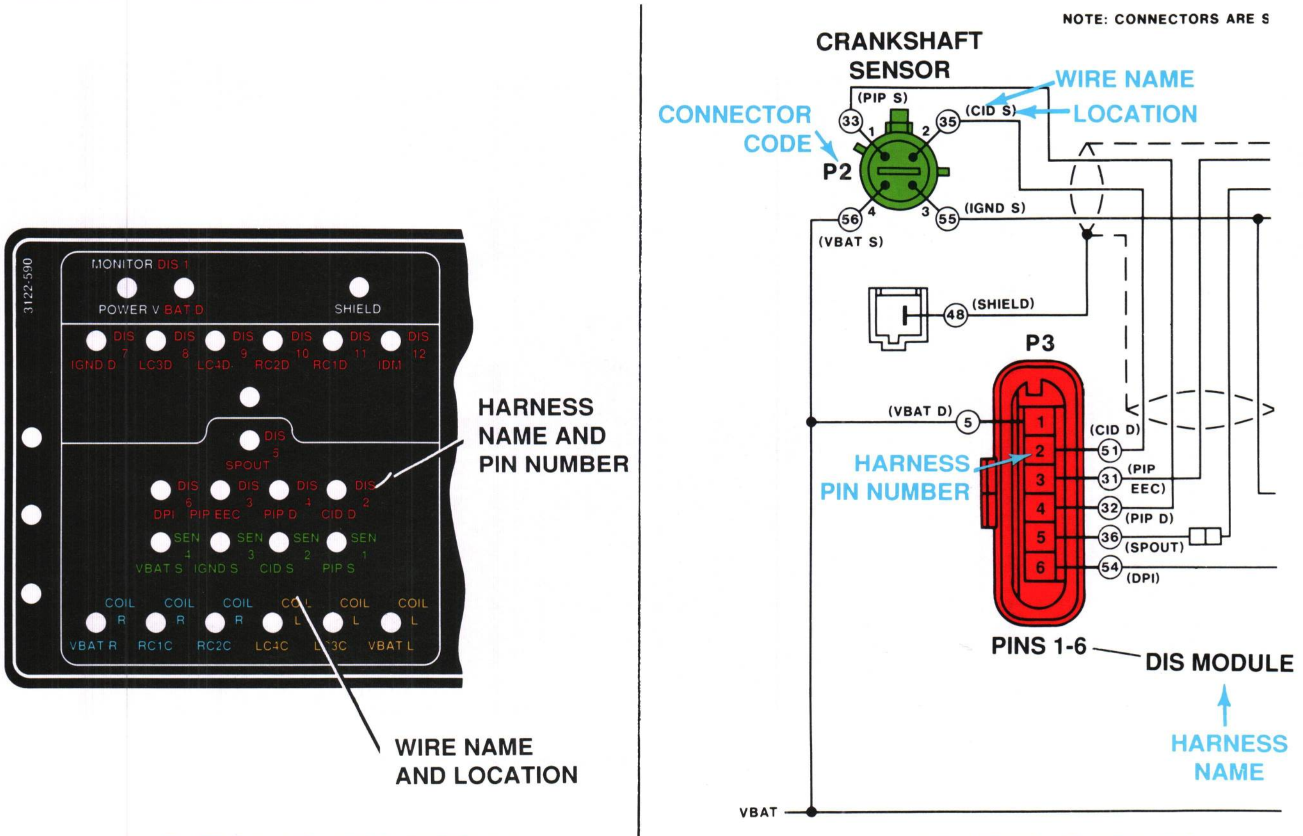


Figure 5-17. 2.3L DP EEC-IV Monitor Overlay



2.3L DP EEC-IV MONITOR OVERLAY

2.3L DP WIRING SCHEMATIC

Figure 5-18. LED's are Labeled and Numbered

DIAGNOSING AND TESTING DIS

Attach the 60-pin connector to the monitor. Be sure the red and black clips of the DIS diagnostic harness are securely attached to the battery.

With the ignition key OFF and the proper overlay installed, turn the monitor power switch to ON and perform the following test:

- Power Test

  Check to see if the MONITOR POWER signal light is lit. Other LED's may randomly light. If the MONITOR POWER LED does not light, then check the battery power and ground clips, the DIS harness 60-pin connection, and the vehicle battery.

- Light Test

  Move LIGHT TEST switch to TEST and check that all panel lights are lit, including 6 yellow lights in the remote display, and the audible tone sounds. Return switch to NORM after verification.

- Monitor Remote Display Test

  Push the button on the remote display unit. Check for display " - 1888". Temperature extremes above 158°F (70°C) will result in a black display; at cold extremes display will run slow. Display will return to normal during normal ambient temperature.

DIS TESTING

Testing DIS with the diagnostic harness and the EEC-IV monitor is similar to diagnosis of the EEC-IV system using the monitor. After completing the visual inspection, the preliminary checks and the Self-Test, you may suspect certain DIS components. Then, from the "Symptom Analysis Charts" in Volume H, select the DIS signals you want to test. In addition, DIS signals at various operating conditions are listed in the "DIS Diagnostic Reference Charts" in Volume H. Depending on the symptom, testing can be done either in a KOEO or KOER condition.

As an example, for "No Start, Stalls" symptom, KOEO testing may be necessary. Start checking values and observe monitor LED's. DCV wiggle testing can be performed to locate intermittent wiring problems.

Through observation of monitor LED's and use of the "Symptom Analysis Charts," most open and short faults can be detected. The "Symptom Analysis Charts" lists "DIS Signals," "Monitor Readings," and "Probable Fault." Compare the LED status on the monitor to the "Monitor Readings" on the chart. Then check the "Probable Fault" to isolate the cause of the symptom.

Keep in mind that some LED's are active high while other LED's are active low. Active high means the LED is lit when the normal input signal is high and the LED is OFF when the input signal is low or missing. Active low means the LED is lit when the normal input signal is low and the LED is OFF when the input signal is high (Figure 5-19).

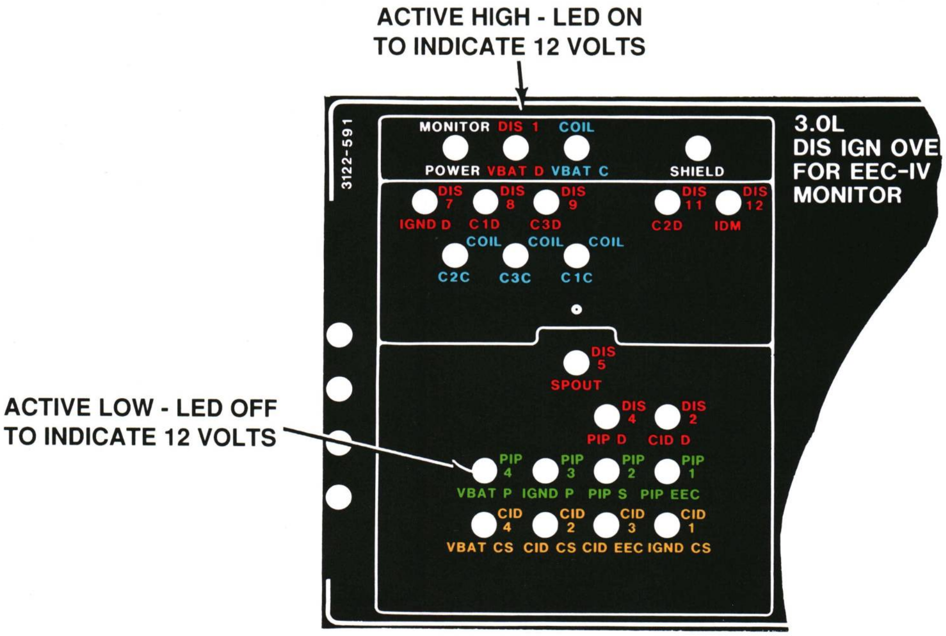


Figure 5-19. LED's Either Active Low or Active High

For example, the battery voltage signal to the DIS module is active high. Therefore, the normal status of the LED labeled DIS 1 VBAT D is ON to indicate 12 volts to pin 1 of the DIS module. However, the battery voltage signal to the 3.0L SHO PIP sensor is active low. The normal status of the LED labeled PIP 4 VBAT P is OFF to indicate 12 volts to pin 4 of the PIP sensor.

An irregular PIP, SPOUT or CID signal can be the result of a harness fault but also can be caused by a defective DIS module, sensor, or EEC-IV module. By comparing your results to the values in the "Diagnostic Reference Charts," a fault can be traced to a single component or circuit.

Several types of signals are measured on the EEC-IV monitor. These signals include battery voltage, grounds, coils, PIP, SPOUT, IDM, CID and DPI. DPI, of course, is only on 2.3L DP engines. The "Diagnostic Reference Value Charts" list the DIS components and several engine operating conditions. The status of the monitor LED and VALUE, such as DC volts or RPM, are noted for each component at each operating condition.

As you can see, Volume H is required to properly diagnose DIS.

USING THE DIS MODULE AND COIL/SENSOR TESTERS

The DIS module tester and the DIS coil/sensor tester may be used instead of the DIS diagnostic cable with the EEC-IV breakout box or EEC-IV monitor. The testers are used to diagnose the distributorless ignition systems on the 3.8L SC, 3.0L SHO and 2.3L DP engines. These hand-held testers provide visual indication of DIS signals and allow easy access to all DIS connections via the test jacks. The DIS module tester monitors all input and output signals involved with the DIS module. The DIS coil/sensor tester monitors all the signals that enter or exist the DIS coil pack, PIP sensor and CID sensor.

The TEE's of the cable connectors on the testers are installed in the same way as the TEE's of the diagnostic harness. With the TEE's connected, the ignition system remains functional and allows you to monitor the DIS circuits. Like the EEC-IV monitor, the LED's show the activity of the ignition system components. This means that components and circuits that are operating properly can be identified without using a volt-ohmmeter.

The following descriptions and examples show how to use the module tester and the coil/sensor tester to diagnose DIS. However, for complete diagnostic procedures, refer to Volume H and the instruction manual for each tester.

DIS Module Tester

The DIS module tester is used to check the input and output signals, including battery voltage and ignition ground, of the DIS module. Each LED is labeled and identifies the specific input or output signal. The test jacks at each LED are numbered. The LAMP TEST button is used to test the LED's (Figure 5-20).

INSTALLATION

For easy identification, the TEE's of the module tester are labeled (Figure 5-21). To install the DIS module tester to the engine wiring harness, follow these steps.

1. Turn the ignition key OFF before connecting or disconnecting the engine harness connectors or

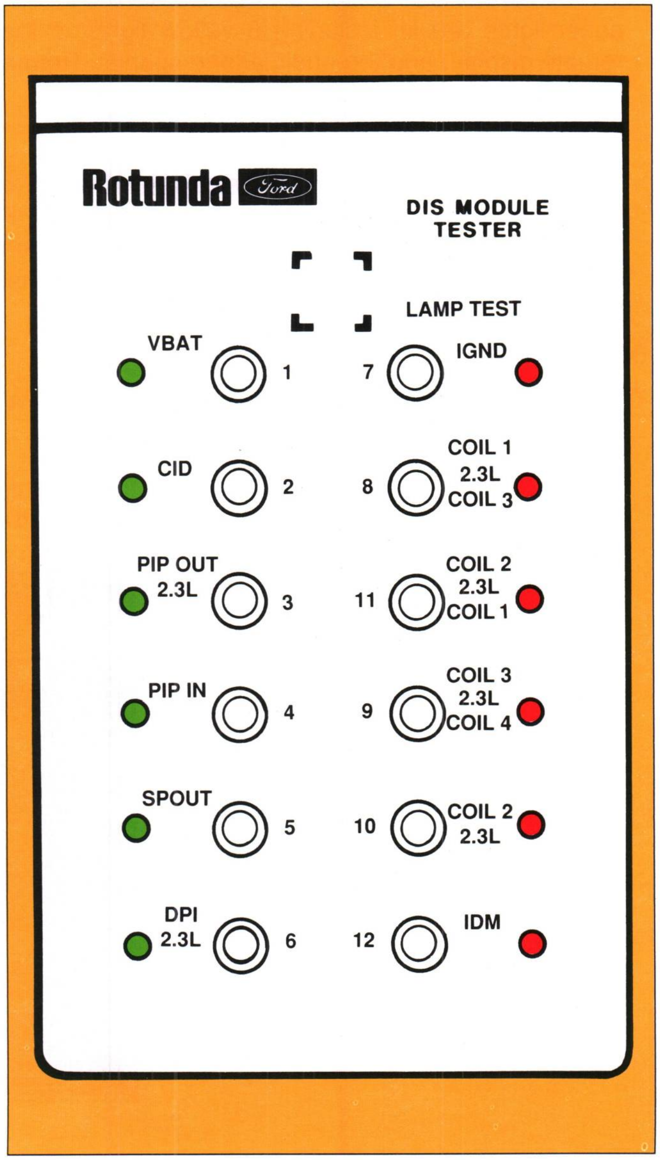


Figure 5-20. DIS Module Tester

the tester connectors. Inspect all connectors for loose pins, damaged pins, corrosion, or loose wires.

2. Route the tester cables away from spark plug wires, moving parts of the engine, hot engine components, or other obstructions.

   Safe placement of the cables will avoid damage from interference during engine operation. Wire ties can be used to attach the cables to fixed engine locations.

3. Disconnect the engine wiring harness from the input side of the DIS module. The input side of the module has the numbers "1" and "6" embossed on the module. Connect the SPOUT TEE of the tester to the input side of the DIS module and the engine harness. Push each connector until the locking tabs click into place. The button on the SPOUT TEE is used to open the SPOUT line during diagnosis.

4. Disconnect the engine wiring harness from the output side of the DIS module. The output side of the module has the numbers "7" and "12" embossed on the module. Connect the IDM TEE of the tester to the output side of the DIS module and the engine harness. Be sure the connectors lock into place. The button on the IDM TEE is used to open the IDM line during diagnosis.

5. Attach the black clip of the tester to the negative terminal of the battery.

TESTING THE DIS MODULE

The DIS module tester monitors the DIS module input and output signals. By watching the LED's of the tester, you can determine if the DIS module is receiving the correct input and responding with the correct output signals. These signals are either pulsed or constant.

For example, VBAT and IGND signals are constant. Other signals are pulsed, such as CID, SPOUT or PIP.

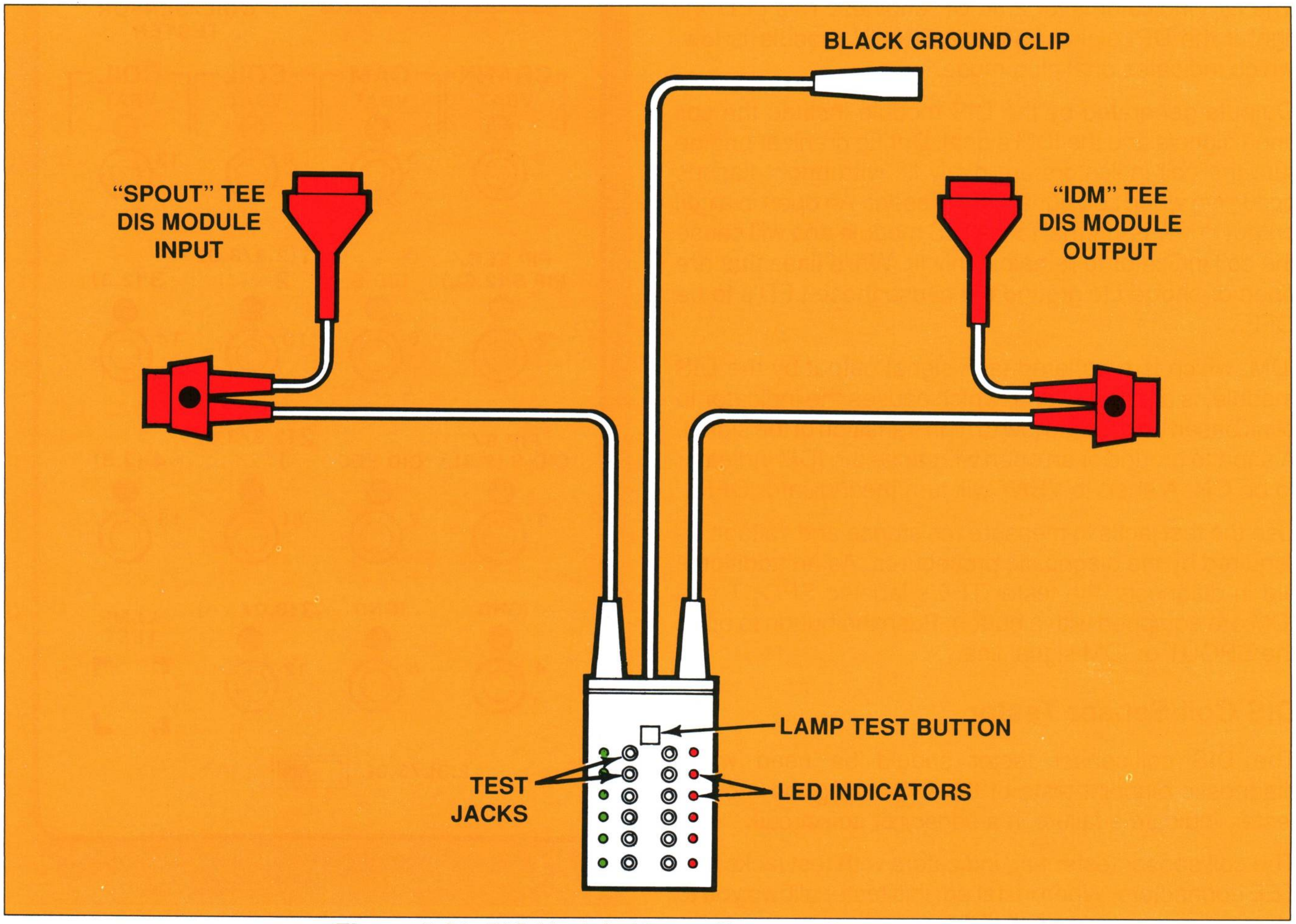


Figure 5-21. DIS Module Tester Harness Connectors

DIAGNOSING AND TESTING DIS

When connected to the DIS module, the tester receives power through the VBAT connection of the DIS module. The ground connection is made when the external ground clip is attached to the vehicle ground. If battery voltage to the DIS module is present, the VBAT indicator will be ON. Otherwise, all the LED's will be OFF. An open ground will turn the IGND indicator OFF, but VBAT will remain ON due to the external ground connection.

Pulsed input signals to the DIS module, such as SPOUT, CID or PIP OUT, flicker or blink as the signal changes from low to high to low. Shorts to VBAT on these lines will cause the indicators to remain constantly ON. Shorts to ground cause the indicators for these lines to remain OFF. Open lines will turn OFF the indicators. A bad sensor can turn the indicator ON or OFF, depending on the type of sensor failure.

The PIP IN indicator will only light when a pulsed input signal is present. A shorted PIP IN line to battery voltage or ground, a bad sensor, or an open line will turn OFF the indicator.

The DPI indicator is for 2.3L DP engines. This LED will light if the DPI signal from the EEC-IV module is low, which indicates dual plug mode.

Outputs generated by the DIS module include the coil firing signals and the IDM signal. During crank or engine run, the coil indicators are dimly lit, with bright flashes occurring when coil signals are present. An open in a coil output driver is internal to the DIS module and will cause the coil indicator to remain dimly lit. While lines that are open or shorted to ground will cause these LED's to be OFF.

IDM, which is a buffered tach signal output by the DIS module, is a pulsed signal which causes the indicator to blink based on a high to low to high transition of the signal. A short to ground or an open will cause the IDM indicator to be ON. A short to VBAT will turn the indicator OFF.

Use the test jacks to measure resistance and voltage as required by the diagnostic procedures. As an additional aid in diagnosis, the tester TEE's labeled SPOUT and IDM are equipped with a button. Push the button to open the SPOUT or IDM signal line.

DIS Coil/Sensor Tester

The DIS coil/sensor tester should be used when diagnostic pinpoint tests of the DIS, using the module tester, indicate a failure in a sensor or coil circuit.

The coil/sensor tester has indicators with test jacks and TEE connectors. When installed, this tester allows you to plug in directly at any or all of the sensor and coil circuits. This tester can be used to check signals sent by the sensors and the signals received by the coil packs, including battery voltage and ignition ground. Each LED is labeled and identifies the specific signal. The test jacks are numbered. The LAMP TEST button is used to test the LED's (Figure 5-22).

The tester also has an engine selector switch. The switch is labeled "2.3L/3.0L" and "3.8L." The switch must be positioned to match the engine being tested. For easy identification, the signals specific to 3.8L engines are highlighted in yellow.

INSTALLATION

For easy identification, the TEE's of the coil/sensor tester

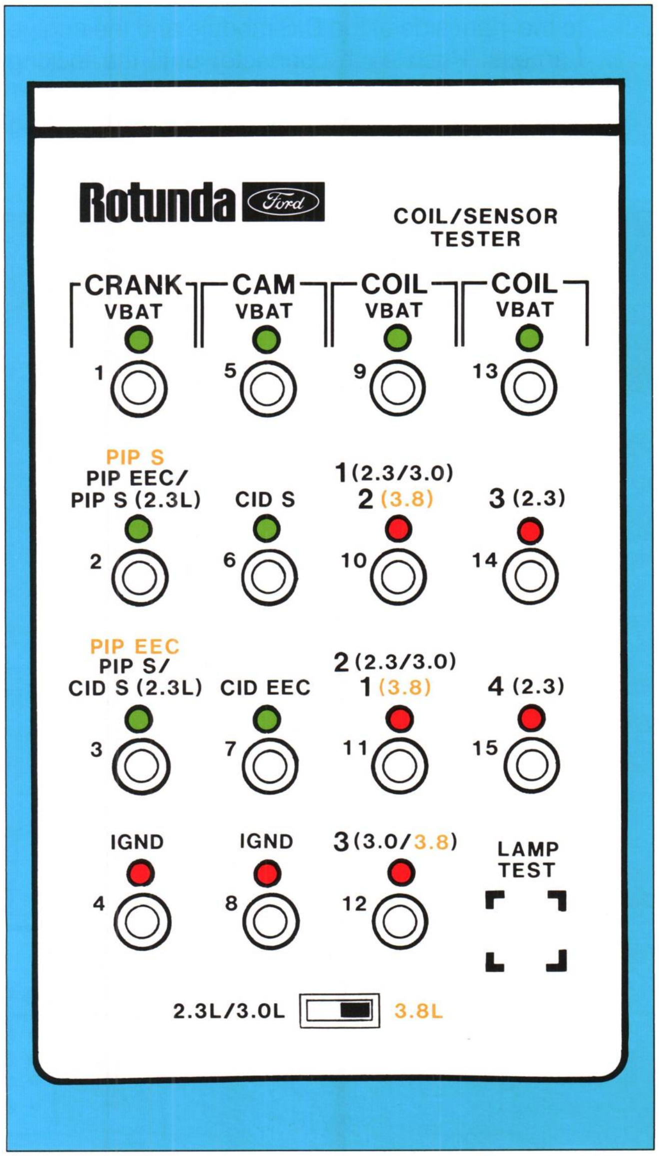


Figure 5-22. DIS Coil/Sensor Tester

are labeled (Figure 5-23). To install the DIS coil/sensor tester to the engine wiring harness, follow these steps.

1. Turn the ignition switch OFF before connecting or disconnecting the engine harness connectors or the tester connectors. Inspect all connectors for loose pins, damaged pins, corrosion or loose wires.
2. Route the tester cables away from spark plug wires, moving parts of the engine, hot engine components, or other obstructions.

   Safe placement of the cable will avoid damage from interference during engine operation. Wire ties can be used to attach the cables to fixed engine locations. Specifically, the cable of the CID sensor on the 3.8L SC must be secured away from the drive belts.
3. Disconnect the engine wiring harness from a component such as a sensor. Connect one end of the tester cable TEE to the component. Then connect the other end of the TEE to the engine wiring harness. Be sure the connections are secure. Some connectors lock into place.

- Use the following TEE's on 3.8L SC and 3.0L SHO engines:
  - Connect the COIL TEE to the six-tower coil pack.
  - Connect the CAM TEE to the CID sensor.
  - Connect the SENSOR TEE to the PIP sensor. Do not disconnect the shield ground connector from the engine wiring harness at the PIP sensor.
- On 2.3L DP engines, use the following TEE's:
  - Connect the R COIL TEE to the right coil pack.
  - Connect the L COIL TEE to the left coil pack.
  - Connect the SENSOR TEE to the dual Hall sensor. Do not disconnect the shield ground connector from the engine wiring harness at the dual Hall sensor.

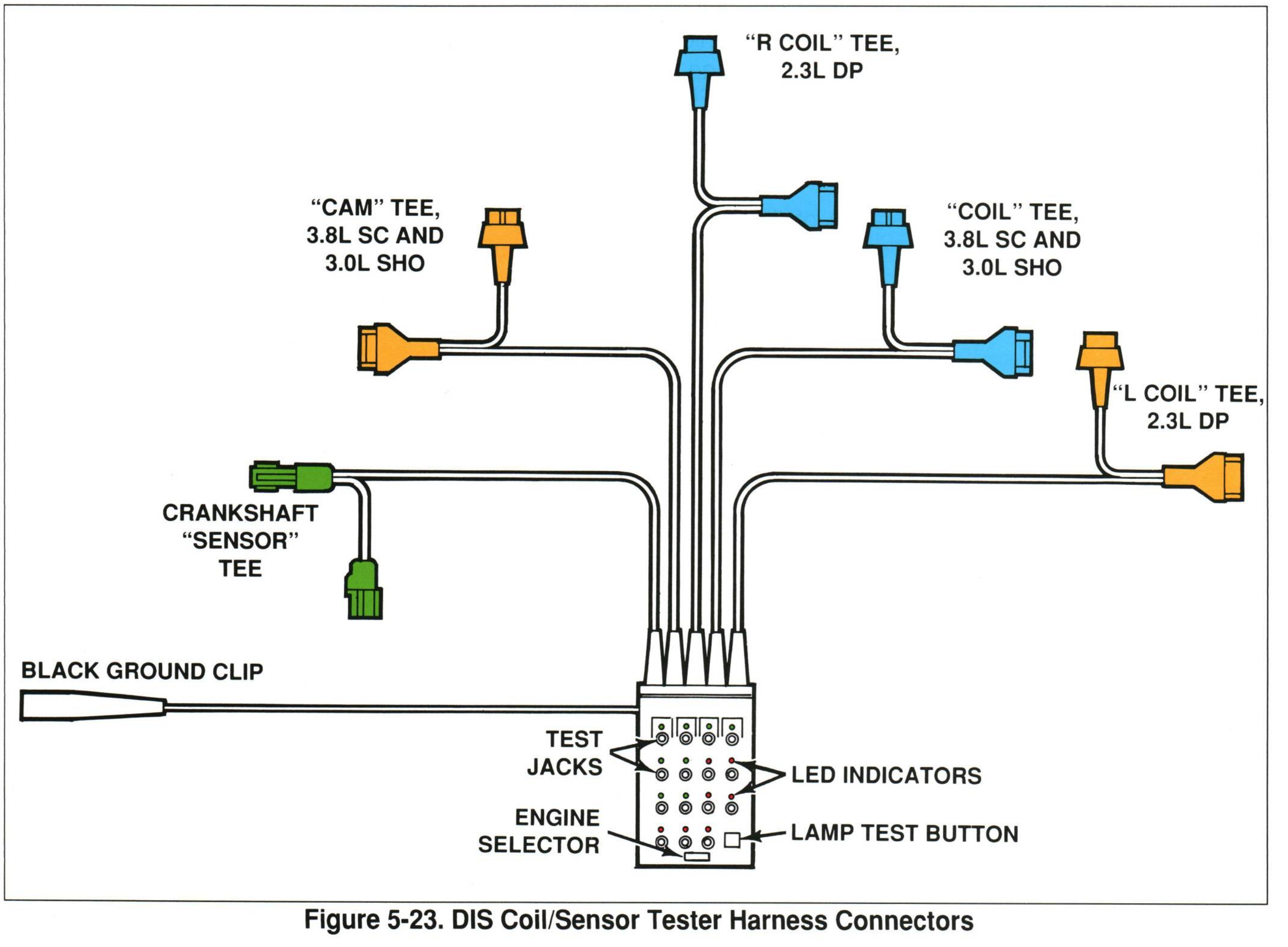


Figure 5-23. DIS Coil/Sensor Tester Harness Connectors

4. Set the engine selector switch to "2.3L/3.0L" or "3.8L" depending on the engine you are diagnosing.
5. Attach the black clip to the negative terminal of the battery.

TESTING COILS AND SENSORS

The DIS coil/sensor tester monitors signals sent by the sensors and signals received by the coils. The tester also monitors battery voltage and ground at the sensors and coils. To determine if the correct signals are being sent or received, watch the LED's on the tester. These signals are either pulsed or constant.

CID, SPOUT or PIP, for example, are pulsed signals while VBAT and IGND signals are constant.

When connected, power to the tester is obtained from any one sensor or coil circuit, since all circuits have a VBAT connection. The power ground connection is made by attaching the tester ground clip to vehicle ground. For VBAT, the indicator will be ON if voltage is present. Opens or shorts to ground will turn the LED's OFF. The IGND indicator(s) will be ON if the system ground is present and OFF if an open line exists.

There are differences in the operation of the sensor LED's versus the coil LED's. For example, due to the characteristics of the crank sensor signals, PIP S and PIP EEC blink. These indicators flicker only when pulsed signals that is, low to high to low transition of the signals, are present. Open lines, bad sensors, or shorts to VBAT or ground will turn OFF the indicators, revealing a crank sensor circuit failure.

The CID sensor signals, such as CID S and CID EEC, flicker when pulses are present. However, a short to VBAT on these lines will cause the indicators to remain ON. Open or shorted lines to ground will turn OFF the indicators. A defective sensor can cause the indicator to turn ON or OFF, depending on the type of sensor failure.

The coil LED's respond in the same manner as the module tester. During crank or engine run, the coil indicators will be dimly lit with bright flashes occurring when coil signals are present. Open lines, open coils, or shorts to ground turn the LED's OFF.

Just like the module tester, use the test jacks of the coil/sensor tester to measure resistance and voltage as specified by the diagnostic procedures.

Remember, the key to diagnosing DIS is to determine the presence of proper outputs and inputs. Once a fault is located, perform the necessary repairs. Then verify the problem was solved. Refer to "SERVICING DIS" for important information about servicing DIS and replacing DIS components.

SERVICING DIS

INTRODUCTION

The diagnosis and testing results from Volume H may lead to servicing DIS components. This section will cover some important points in regard to servicing DIS.

These procedures are not intended to replace shop manual procedures, but only serve to outline and emphasize differences for DIS.

For complete service instructions on 3.8L SC, 3.0L SHO or 2.3L DP engines, refer to the appropriate shop manual.

DIS MODULE

Keep in mind that the DIS module and the EEC-IV module are grounded through the DIS module. In order for DIS and EEC-IV to operate, the DIS module must be installed properly to ensure a good ignition ground (IGND) connection. Without proper ground, the engine will not start.

IGND is a low current reference for the EEC-IV and DIS modules. It is connected to battery negative (ground) via the DIS module metal base plate. Proper system operation depends on this low resistance path. This is not a source for vehicle ground.

The resistance between the negative terminal of the battery and ignition ground (IGND) path, with the key OFF, should be less than 5 ohms. If not, check to be sure the mounting screws of the DIS module are tight before replacing the module.

DIS MODULE REPLACEMENT

The following procedure outlines DIS module replacement for 3.8L SC, 3.0L SHO and 2.3L DP engines. Refer to the appropriate shop manual for complete removal and installation instructions.

1. Disconnect the negative cable from the battery.
2. Disconnect the electrical connectors from the DIS module. Grasp the connector with your thumb on the tab marked "push." While holding the connector body, use thumb pressure to depress the locking tab. Pull the connector from the module. Wiggling the connector will make separation easier (Figure 6-1).
3. Remove the screws securing the ignition module and remove the module.
4. Apply a uniform coating of Heat Sink Grease ESF-M99G123-A, or equivalent, to the mounting surface of the DIS module (Figure 6-2).

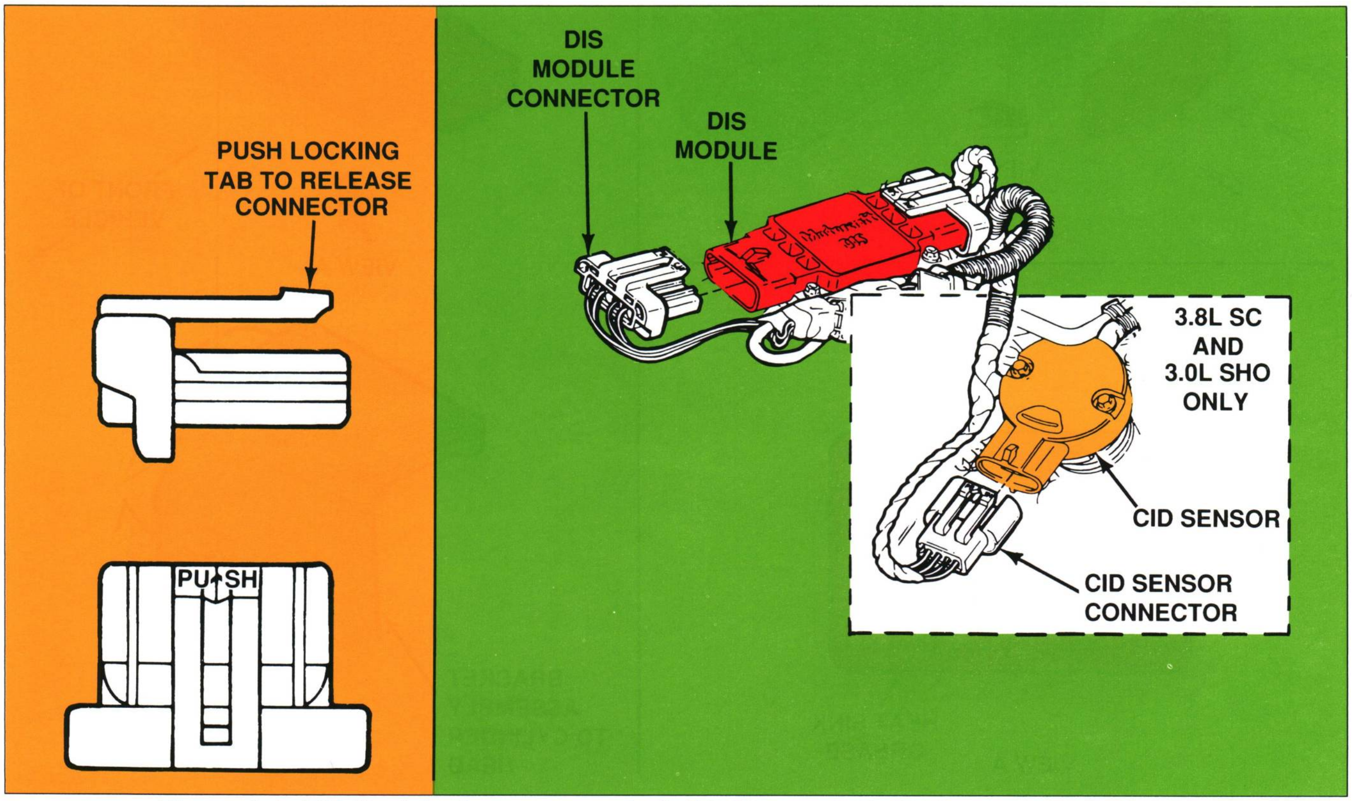


Figure 6-1. DIS Module Connectors - 3.8L SC Shown, 3.0L SHO and 2.3L DP Similar

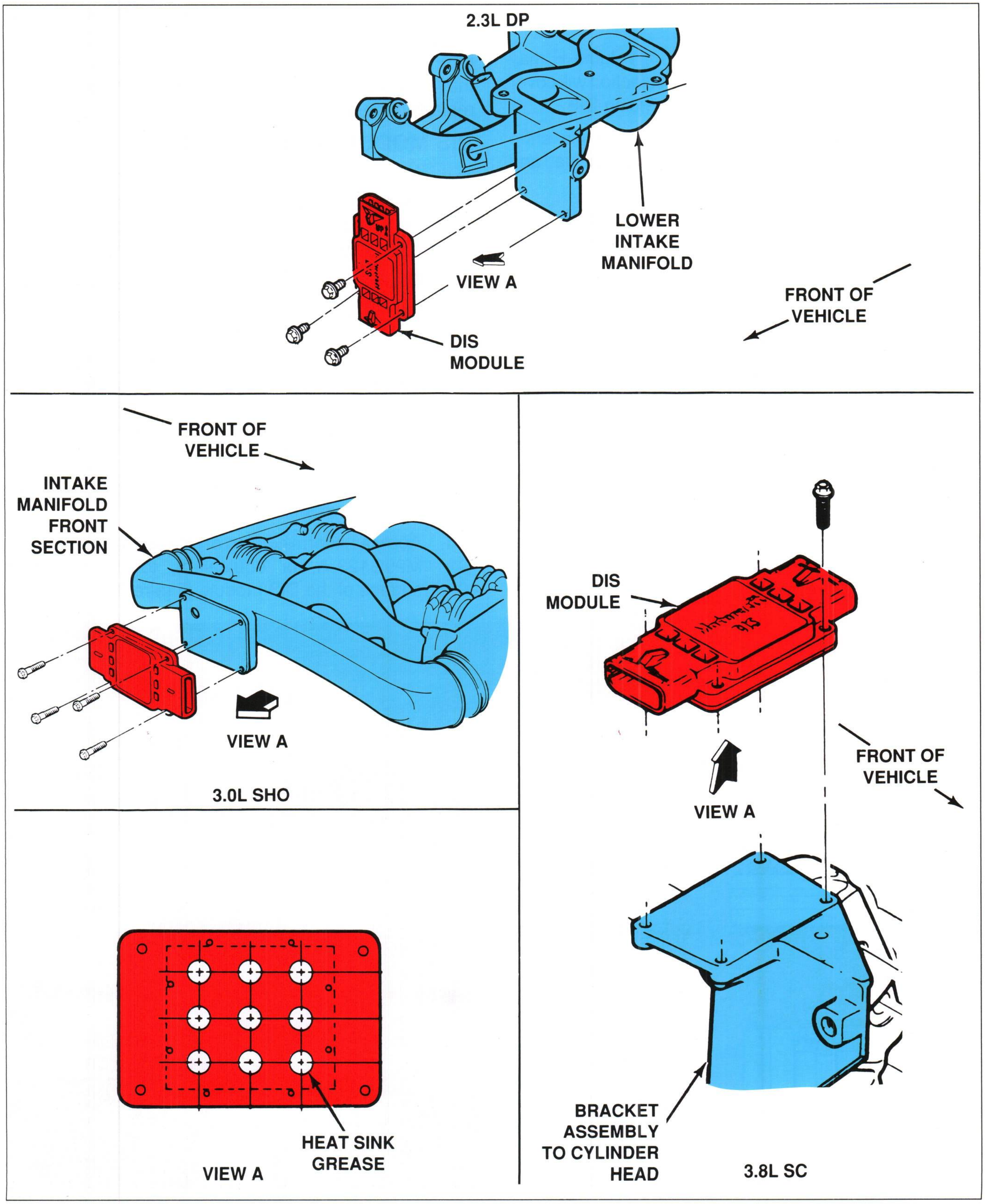


Figure 6-2. DIS Module Installation

5. Position the DIS module and install the mounting screws. Tighten the mounting screws to 2.5-3.5 N•m (22-31 lb. in.).

   The mounting holes in the module have brass inserts which contact the mounting screws.

6. Install the electrical connectors to the module. Be sure the tabs of the connectors lock in place.

7. Connect the negative cable to the battery.

DIS COIL PACK

As explained earlier, each coil within the DIS coil pack is a step-up transformer and operates in basically the same manner as the E-core coil.

During engine operation, the DIS module limits the current to the coils within the coil pack to 5.5 amps. Since automotive batteries can supply 600 amps or more, do not ground the coil pack. Grounding the coil pack will result in approximately 26 amps to the coil. The coil will be destroyed almost instantly.

DIS COIL PACK REPLACEMENT

In general, the following steps explain DIS coil pack replacement for 3.8L SC, 3.0L SHO and 2.3L DP engines. There are some differences in the removal and installation procedures for these engines. For complete procedures, refer to the shop manual for a specific engine.

1. Disconnect the negative cable from the battery.

2. Remove the spark plug wires from the coil pack.

   On 3.0L SHO engines, remove the cover from the coil pack (Figure 6-3).

   To remove the plug wires, squeeze the locking tabs to release the coil boot retainers (Figure 6-4).

   Use a twisting pulling motion to remove the boot. Do not pull on the spark plug wires.

3. Disconnect the engine harness electrical connector from the ignition coil pack.

4. Remove the coil pack mounting screws and remove the coil pack.

5. Position the coil pack on the mounting bracket and install the mounting screws.

6. Before connecting the spark plug wires to the DIS coil pack, apply silicone Dielectric Compound D7AZ-A9A331-A, or equivalent, to the interior surface of the boot.

   Position the boot on the tower of the coil pack. Then push down until the locking tabs click into place (Figure 6-5).

   Be sure each spark plug wire is connected to the proper high voltage tower of the coil pack. Also, be sure the spark plug wires are routed properly and secured to the wire routing brackets (Figure 6-6).

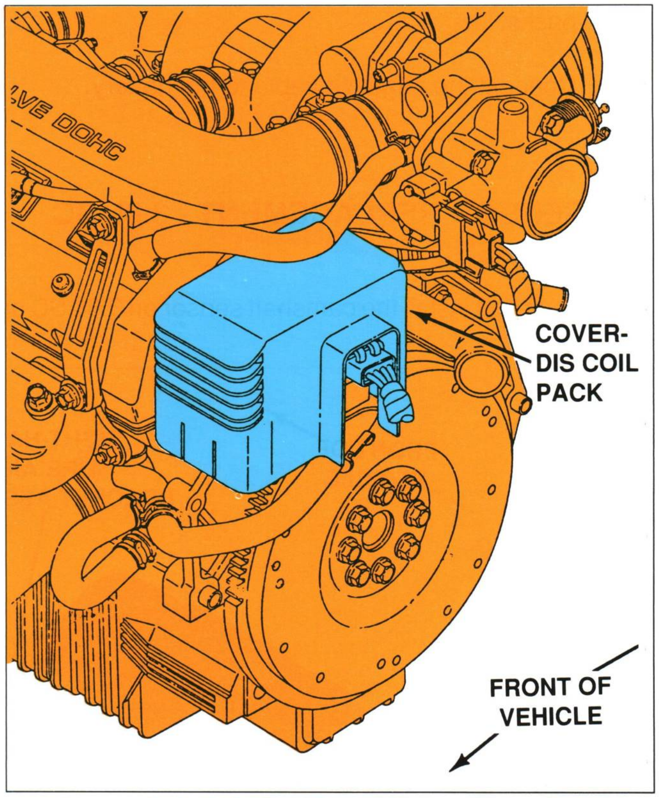


Figure 6-3. DIS Coil Pack Cover - 3.0L SHO

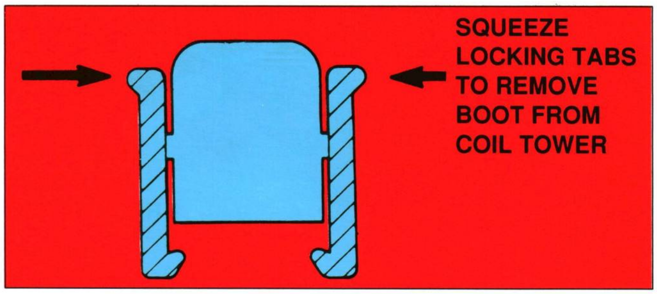


Figure 6-4. Spark Plug Wire Boot at DIS Coil

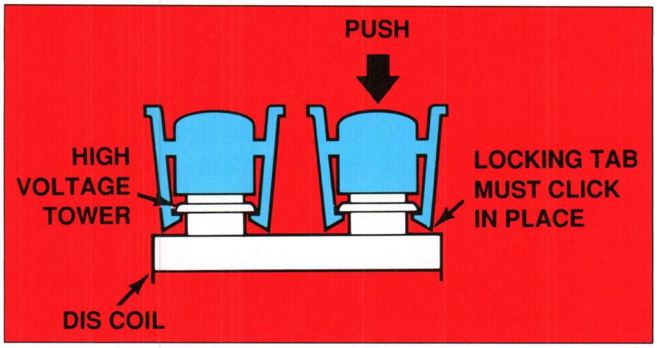


Figure 6-5. Spark Plug Wire Installation at DIS Coil

7. Connect the engine harness electrical connector to the coil pack. Install the cover on 3.0L SHO coil packs.
8. Connect the negative cable to the battery.

DIS SENSORS

CID SENSOR REPLACEMENT - 3.8L SC AND 3.0L SHO

To remove and install the camshaft sensor on 3.8L SC or 3.0L SHO engines, refer to the shop manual for complete directions. The following is a brief description for CID replacement. This description includes important information about the 3.8L SC CID sensor and synchronizer assembly.

Keep in mind that base timing is preset on DIS engines and is not adjustable.

1. Disconnect the negative cable from the battery.
2. Disconnect the electrical connector from the CID sensor (Figure 6-1).
3. Remove the 4 mm screw and washer assemblies that secure the sensor.

3.0L SHO

It is not necessary to remove the mounting adapter in order to replace the CID sensor (Figure 6-7).

3.8L SC

Notice that the 3.8L SC CID sensor is installed where the distributor would be for a conventional ignition system

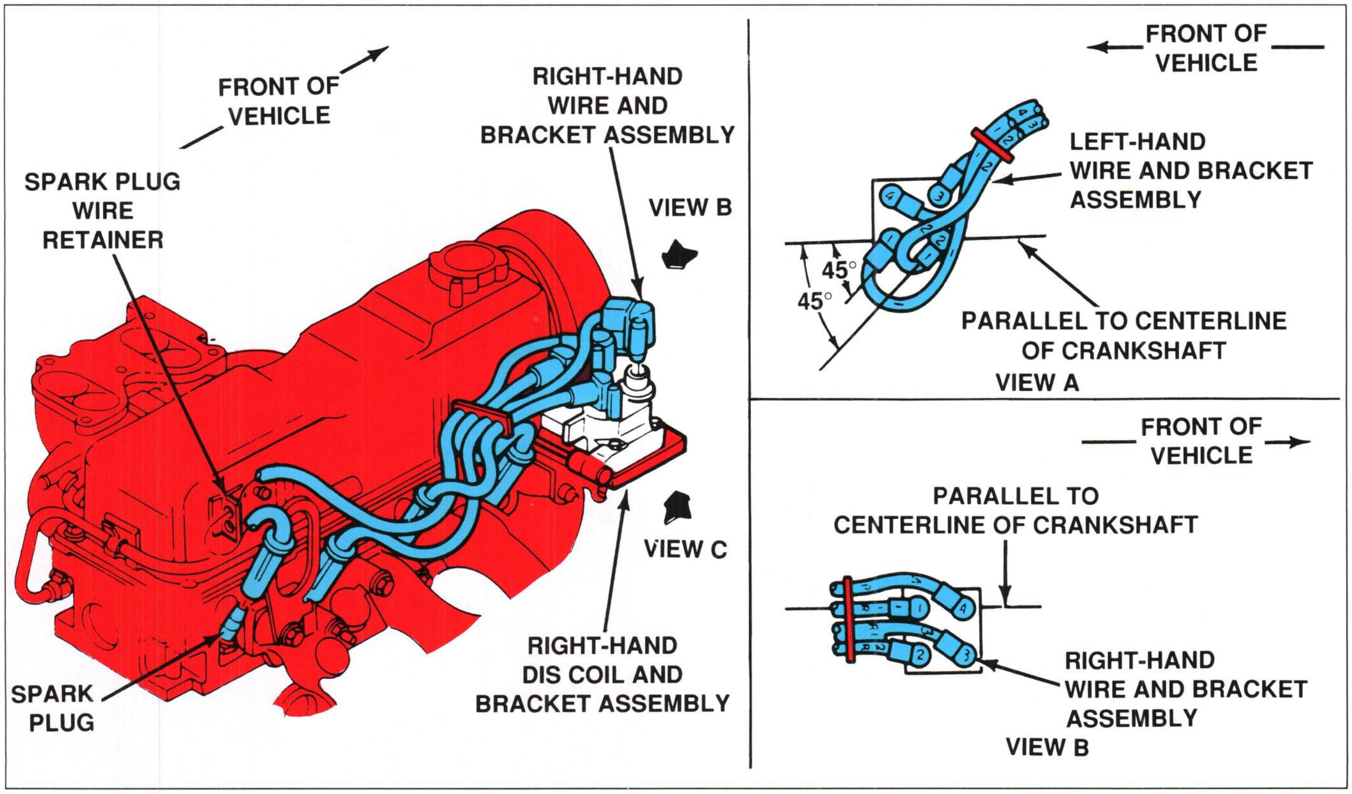

FRONT OF VEHICLE
RIGHT-HAND WIRE AND BRACKET ASSEMBLY
SPARK PLUG WIRE RETAINER
VIEW B
VIEW C
RIGHT-HAND DIS COIL AND BRACKET ASSEMBLY
SPARK PLUG
FRONT OF VEHICLE
LEFT-HAND WIRE AND BRACKET ASSEMBLY
45°
45°
PARALLEL TO CENTERLINE OF CRANKSHAFT
VIEW A
FRONT OF VEHICLE
PARALLEL TO CENTERLINE OF CRANKSHAFT
RIGHT-HAND WIRE AND BRACKET ASSEMBLY
VIEW B

Figure 6-6. Routing Spark Plug Wires - 2.3L DP Shown

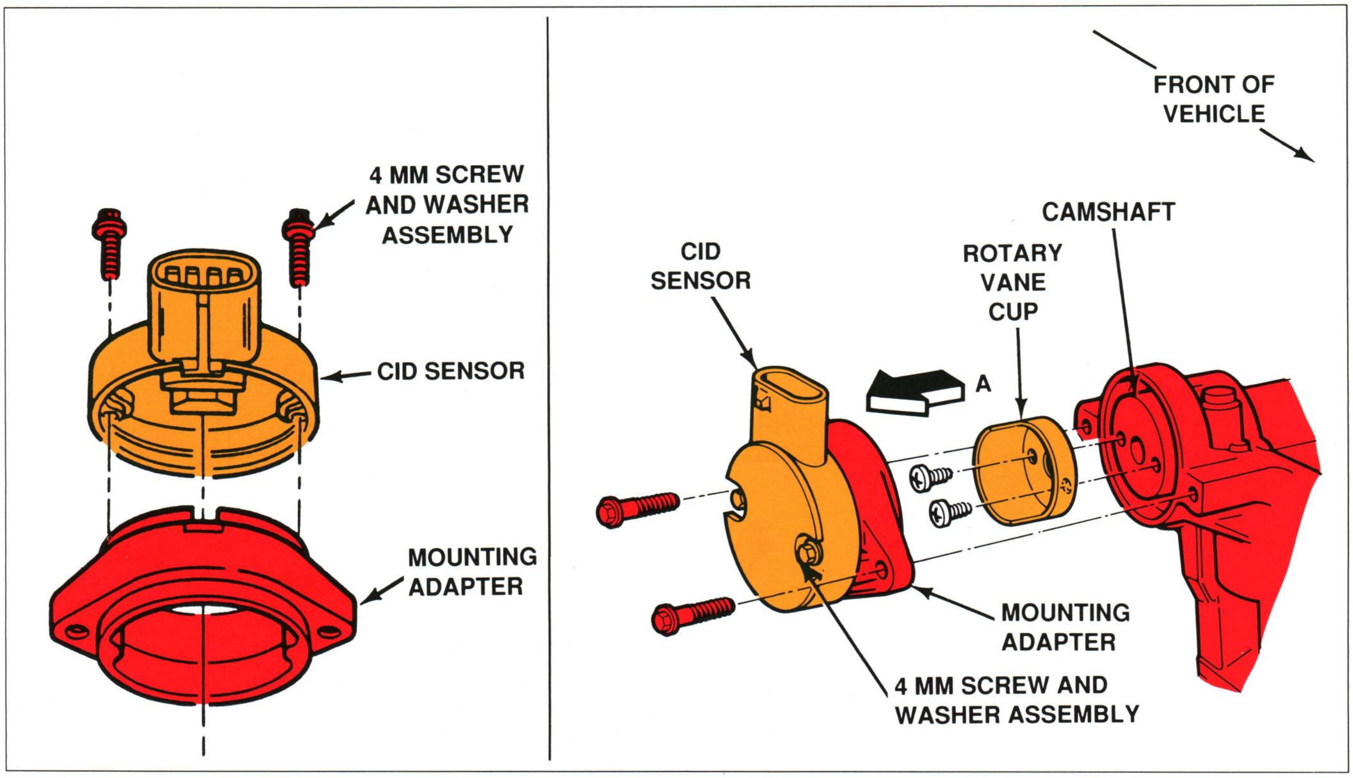


Figure 6-7. CID Sensor Installation - 3.0L SHO

(Figure 6-8). If the synchronizer assembly must be removed, note the relationship of the rotary vane cup and the crankshaft before removing the synchronizer. To install the synchronizer assembly, refer to "CID Alignment - 3.8L SC" in this section. Engine timing will be lost if the synchronizer assembly is not installed correctly.

4. Position the CID sensor and install the 4 mm screw and washer assemblies.
5. Install the electrical connector on the CID sensor.
6. Connect the negative cable to the battery.

CID Alignment - 3.8L SC

If the 3.8L SC synchronizer assembly is removed, use the following installation and alignment procedure to ensure proper engine timing (Figure 6-8).

1. Position piston 1 at 26° ATDC of the compression stroke.
2. Insert the lock ring end of the intermediate shaft into the synchronizer assembly.
3. Install the synchronizer assembly with the intermediate shaft into the front cover assembly. Be sure the arrow of the timing arm locator is positioned as shown (Figure 6-8).
4. Install the tamper resistant bolt and clamp, to secure the synchronizer assembly.
5. Remove the timing arm locator and save it for future use.
6. Install the CID sensor as described earlier.

PIP SENSOR REPLACEMENT - 3.8L SC AND 3.0L SHO

The Hall device of the PIP sensor has a plastic housing. The rotary vane cup is made of ferrous metal and passes through the air gap of the Hall device. The vane cup is part of the crankshaft pulley and damper assembly. Therefore, the alignment of the vane to the air gap of the sensor is critical. If this alignment is not correct, the sensor will be damaged beyond repair when the engine is cranking.

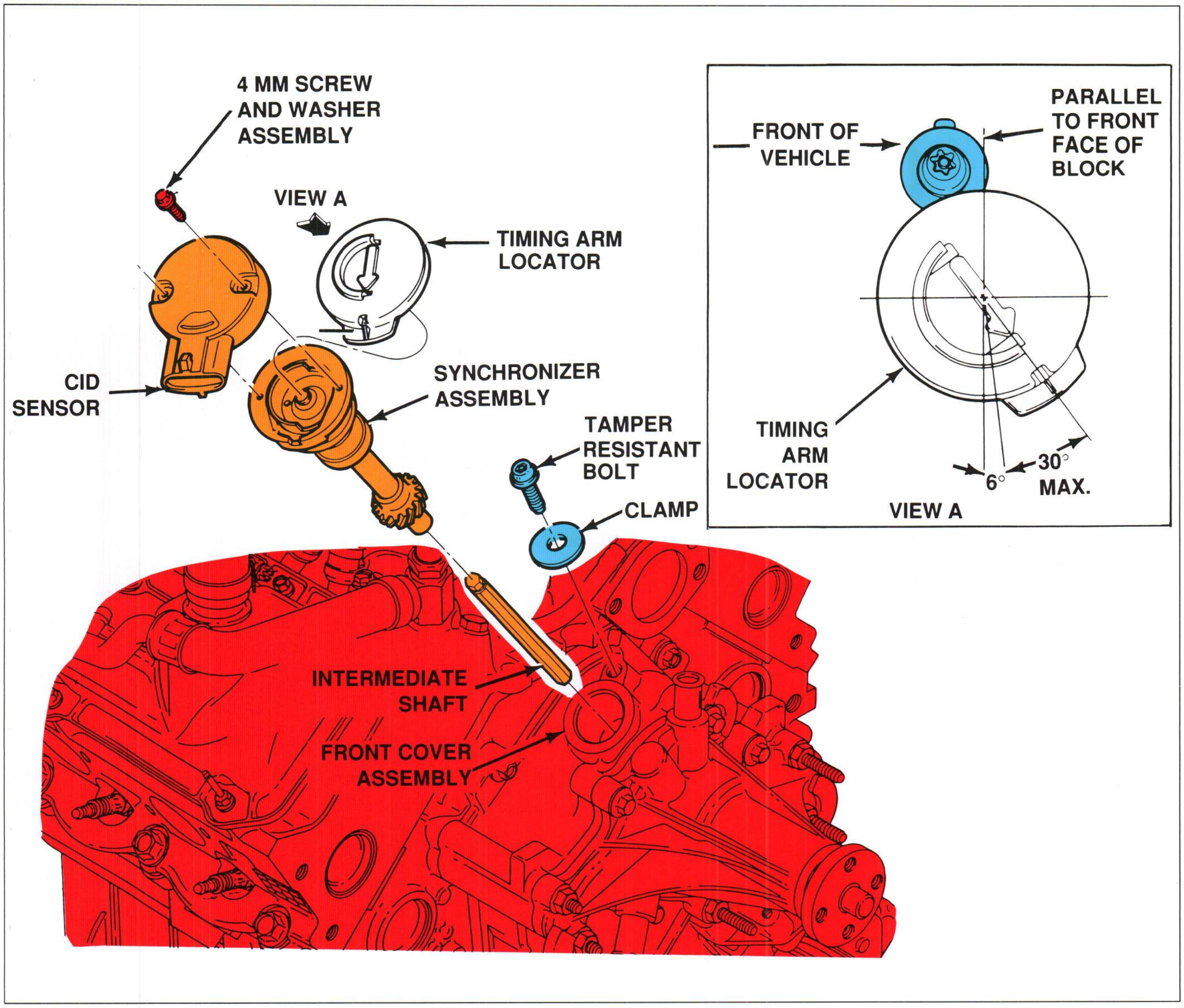


Figure 6-8. CID Alignment - 3.8L SC

To ensure proper installation and alignment of the PIP sensor, review the following procedure.

In order to access the PIP sensor, it will be necessary to remove drive belts, timing cover, crankshaft shield or other components. Therefore, refer to the shop manuals for specific details about the 3.8L SC or 3.0L SHO engines.

1. Disconnect the negative cable from the battery.
2. Disconnect the PIP sensor electrical connectors, the PIP connector and the shield connector. Grasp each end of the connector body. While holding the connector body, use thumb pressure to depress the locking tab. Then pull the connector apart. Wiggling the parts will make separation easier (Figure 6-9).
3. Remove drive belts, covers, and shields as required to remove the crankshaft pulley and

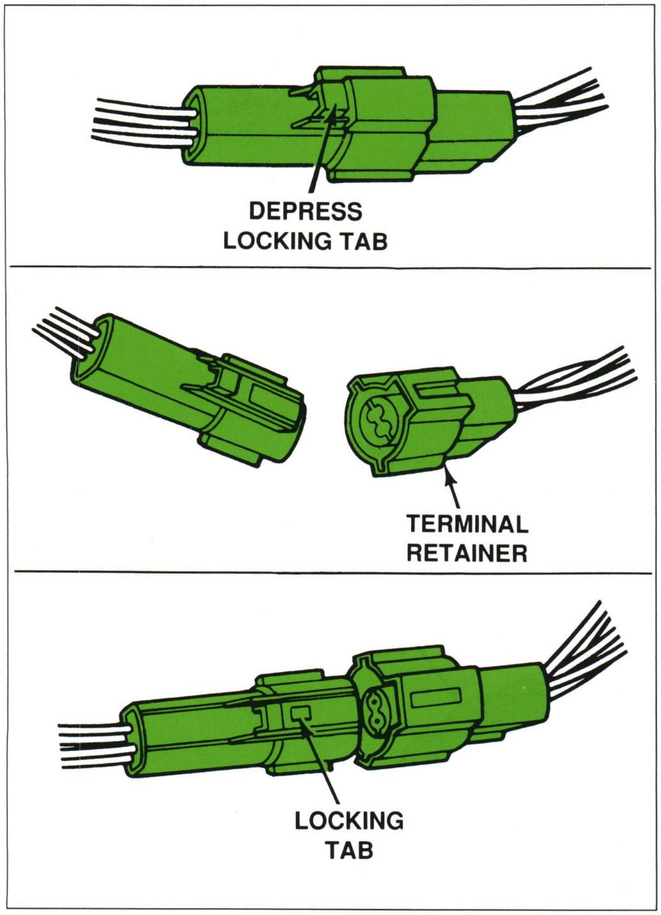


Figure 6-9. PIP Sensor Connector - Typical

damper as an assembly. Do not remove the pulley from the damper because it is balanced as an assembly (Figure 6-10).

4. Remove the PIP sensor mounting screws. Then remove the PIP sensor.
5. Position the PIP sensor and hand start the mounting screws. Do not tighten the mounting screws.
6. Install the crankshaft pulley assembly.
7. Rotate the crankshaft by hand so that a vane, or shutter, of the rotary vane cup is in the gap of the PIP sensor.
8. Using a feeler gauge, set the clearance between the PIP sensor and the vane of the vane cup to 0.8 mm (0.032 inch) (Figure 6-11). Tighten the mounting screws to 2.5-3.5 N•m (22-31 lb. in.).
9. Route the PIP sensor harness and secure the harness in its original position.
10. Install any shields, covers, or belts that were removed during disassembly.
11. Connect the PIP sensor electrical connector and the sensor shield connector to the engine electrical harness (Figure 6-12).
12. Connect the negative cable to the battery.

DUAL HALL SENSOR REPLACEMENT - 2.3L DP

This dual Hall sensor is mounted at the crankshaft. The rotary vane cup is made of ferrous metal and passes through the air gap of the sensor. The vane cup is part of the crankshaft pulley hub assembly, and the sensor must be aligned with the vane cup. If this alignment is not correct, the dual Hall sensor will be destroyed during engine cranking.

A sensor positioner is included with the new dual Hall sensor. Use this positioner to align the vane cup and the air gap of the sensor.

Review the following replacement procedure. For detailed removal and installation steps, refer to the shop manual.

1. Disconnect the negative cable from the battery.
2. Disconnect the dual Hall sensor connector (Figure 6-9) and the shield connector from the engine electrical harness.

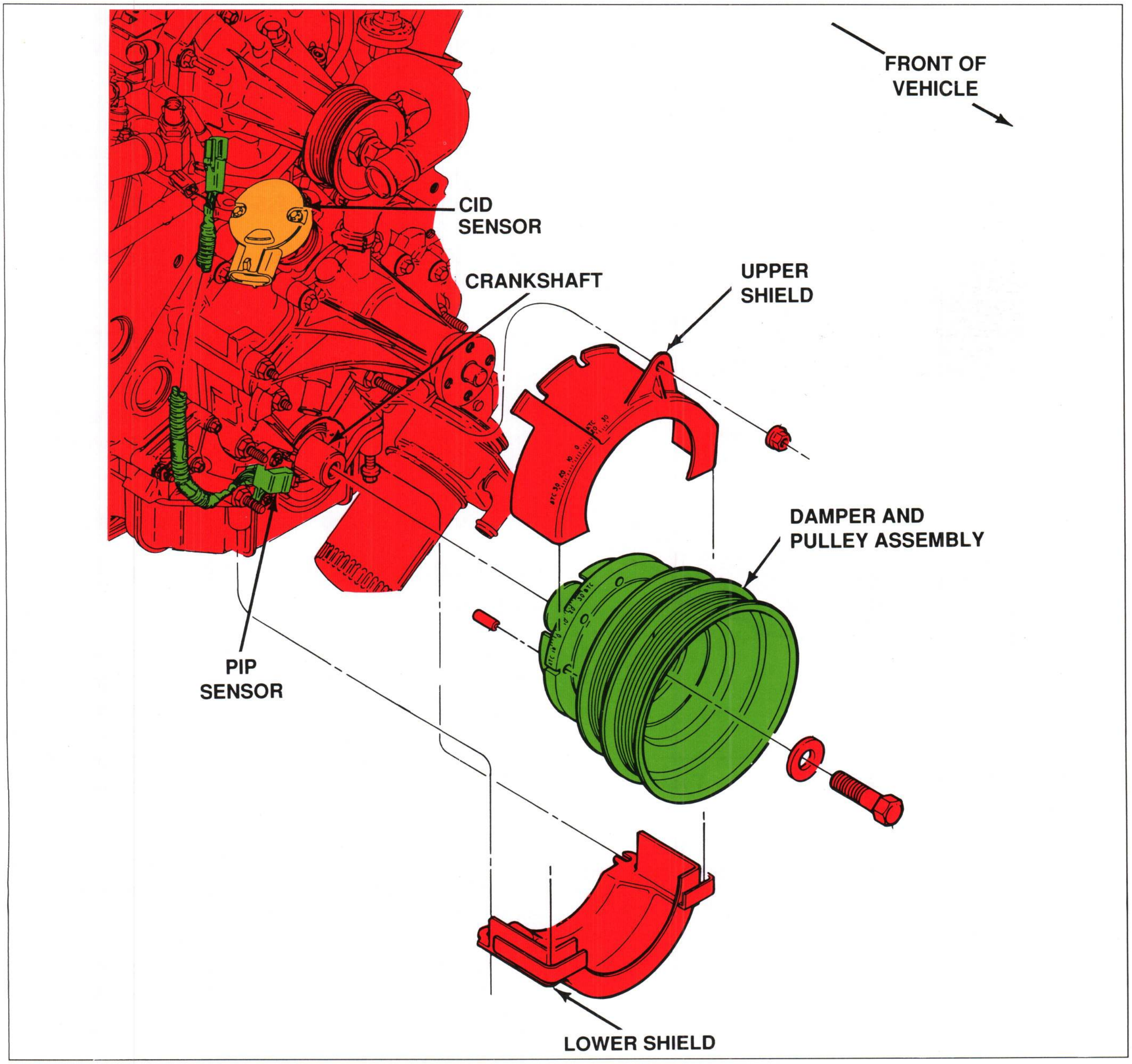


Figure 6-10. PIP Sensor Installation - 3.8L SC

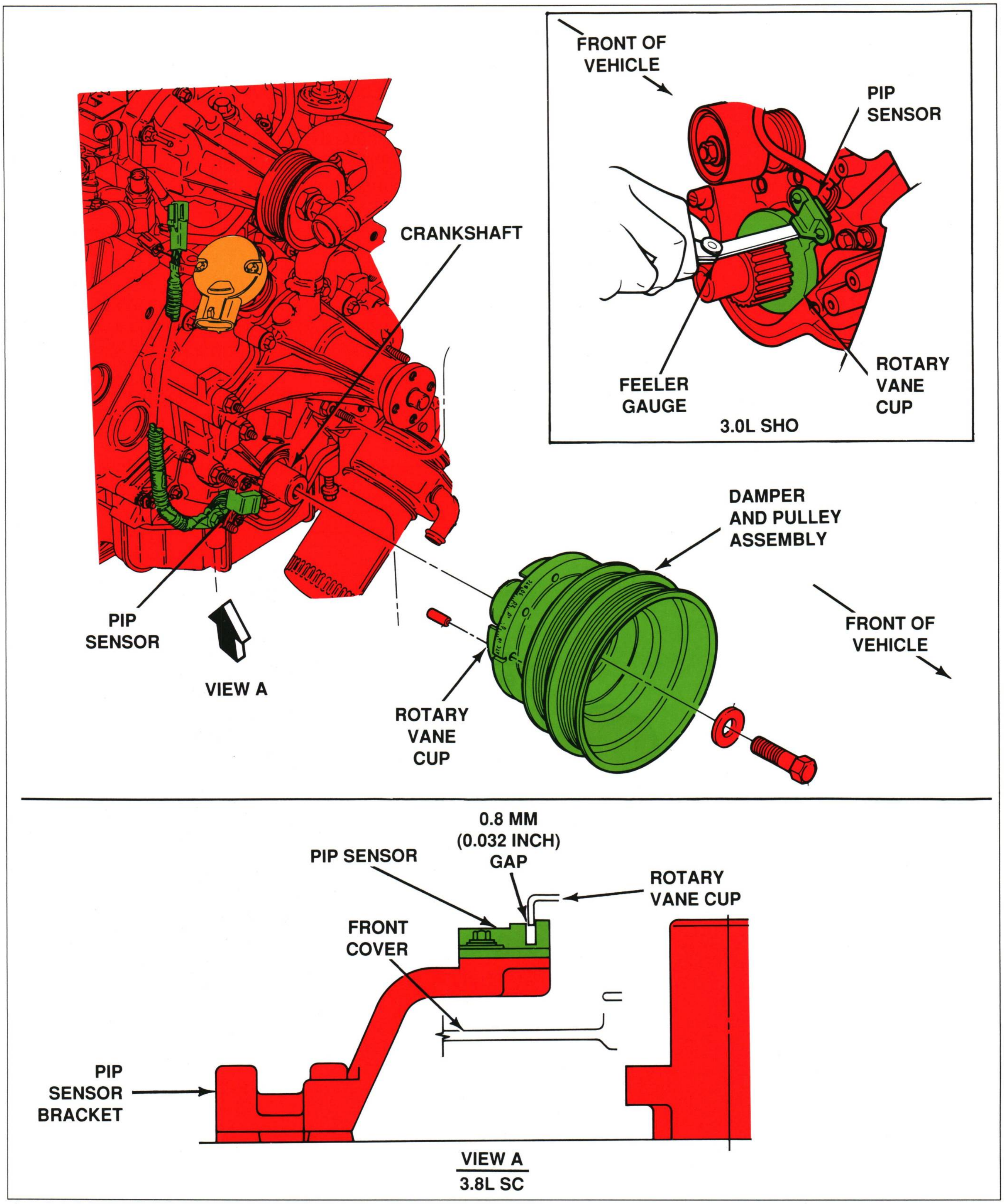


Figure 6-11. PIP Sensor Alignment - 3.8L SC and 3.0L SHO

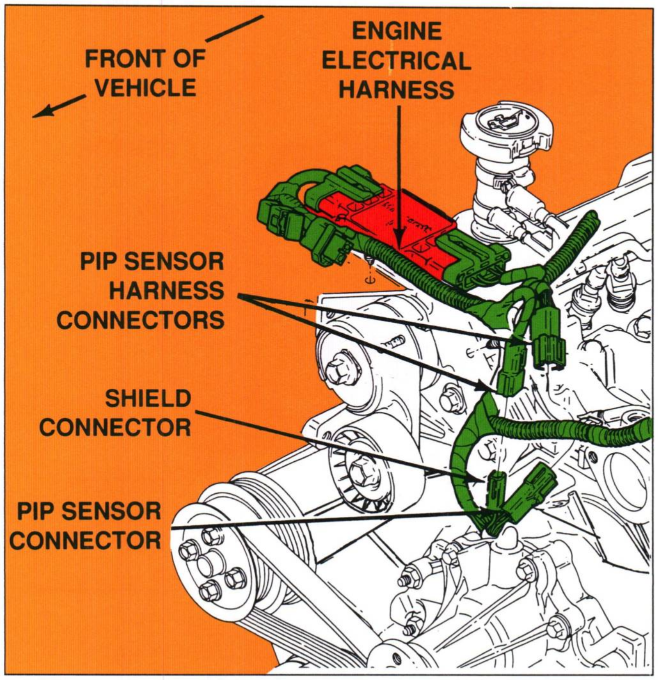


Figure 6-12. PIP Sensor Connectors - 3.8L SC

3. Remove the accessory drive belts. Then remove the crankshaft pulley assembly from the crankshaft pulley hub assembly. Remove the timing belt outer cover (Figure 6-13).

4. To remove the dual Hall sensor, the vane window of both inner and outer vane cups must be aligned with the sensor.

   The vane cups are part of the crankshaft pulley hub assembly.

   When the keyway of the crankshaft is in the ten o'clock position, the windows of the vane cups are aligned with the sensor (Figure 6-13).

5. Remove the sensor mounting screws and the plastic wire retainer. Then remove the sensor.

6. Position the dual Hall sensor on its bracket and hand start the mounting screws. Do not tighten the mounting screws at this time.

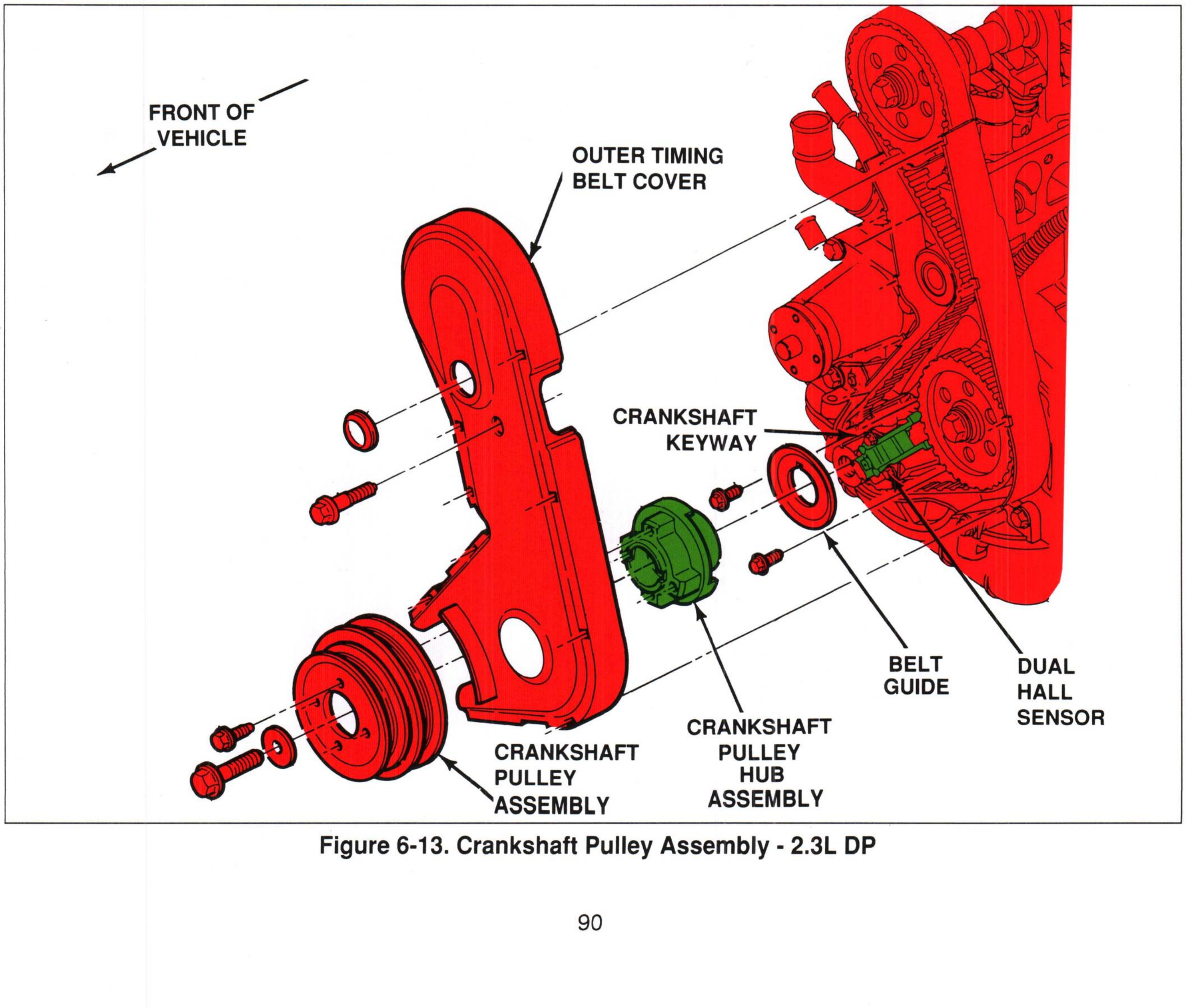


Figure 6-13. Crankshaft Pulley Assembly - 2.3L DP

7. Rotate the crankshaft so that the outer vane on the crankshaft pulley hub assembly engages the Crankshaft Hall Effect Sensor Positioner, tool T89P-6316-A or equivalent. Now, tighten the sensor mounting screws (Figure 6-14) to specification.

8. Rotate the crankshaft so the outer vane no longer engages the positioning tool. Squeeze the tabs of the tool and remove the positioning tool. Install a new plastic wire retainer.

9. Route the dual Hall sensor harness and secure the harness in its original position.

10. Install the timing belt outer cover, the crankshaft pulley assembly, and any components removed during disassembly.

11. Connect the sensor connector and the shield connector to the engine electrical harness.

12. Connect the negative cable to the battery.

REMEMBER THE FOLLOWING:

- initial timing is preset at 10° ± 2° BTDC and is not adjustable.
- the DIS module must be properly grounded to ensure DIS and EEC-IV system operation.
- the 3.8L SC and 3.0L SHO PIP sensors and the 2.3L DP dual Hall sensor must be properly aligned in order to avoid sensor damage.
- do not ground DIS coil packs.

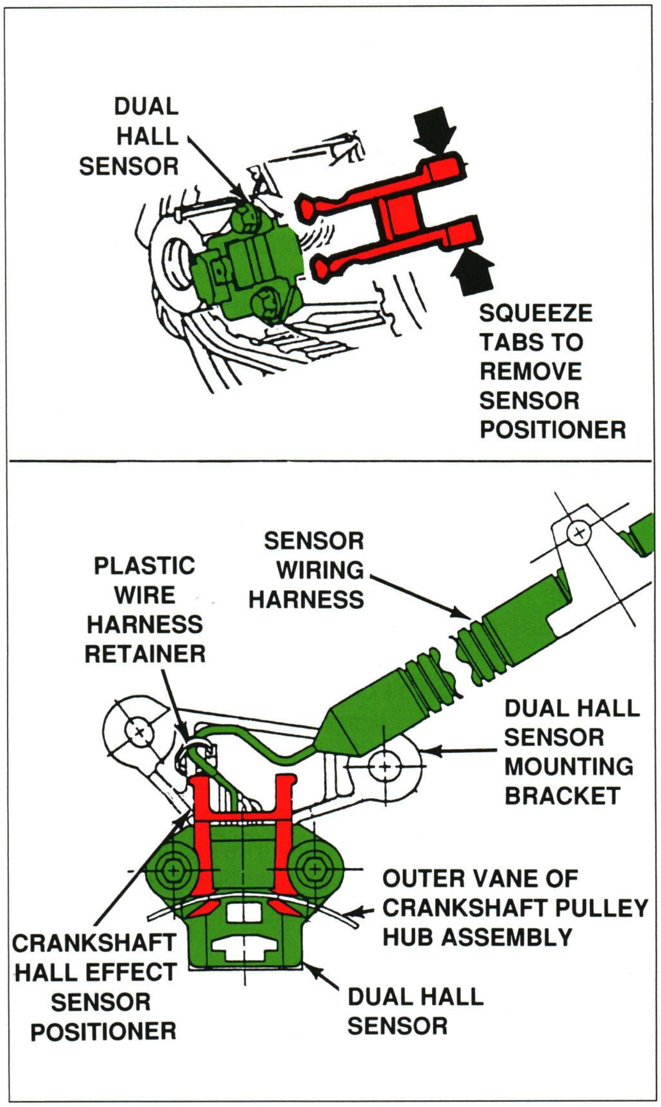

DUAL HALL SENSOR
SQUEEZE TABS TO REMOVE SENSOR POSITIONER
PLASTIC WIRE HARNESS RETAINER
SENSOR WIRING HARNESS
DUAL HALL SENSOR MOUNTING BRACKET
OUTER VANE OF CRANKSHAFT PULLEY HUB ASSEMBLY
CRANKSHAFT HALL EFFECT SENSOR POSITIONER
DUAL HALL SENSOR

Figure 6-14. Dual Hall Sensor Alignment - 2.3L DP

GLOSSARY

AC (ALTERNATING CURRENT) - An electric current that reverses its direction at regularly recurring intervals.

ACTUATOR - Any device, such as a solenoid, which converts electrical energy into mechanical motion.

AIR CHARGE TEMPERATURE (ACT) SENSOR - A device used to measure the temperature of the air/fuel in the intake manifold or in the air filter housing. Sensor output is used to determine injector pulse width or the duty cycle of the feedback control solenoid.

AMMETER - A device used to measure current draw in a circuit; readings are in amperes.

AMPERAGE - The amount of electric current flowing in a circuit as read in amperes (amps).

AMPERE - A unit of measurement for the flow of electric current (See AMPERAGE).

AMPLIFIER - A circuit or device used to increase the voltage or current of a signal.

ANALOG - A continuously variable voltage signal.

ATDC (After Top Dead Center) - The location of a piston after it has reached the top of its stroke. Piston location is measured in degrees of crankshaft rotation.

BREAKOUT BOX (BOB) - A test device which connects to the EEC-IV module or the ignition system and permits circuit measurements of the EEC-IV system or the DIS module, sensors and coils.

BTDC (Before Top Dead Center) - The location of a piston before it has reached the top of its stroke. Piston location is measured in degrees of crankshaft rotation.

CAMSHAFT POSITION SENSOR - See CID.

CCD (Computer Controlled Dwell) - Feature of EEC-IV system using DIS in which trailing edge of SPOUT determines when coil primary current turns ON and leading edge determines when coil primary current turns OFF.

CID (Cylinder Identification) Sensor - Hall effect sensor which generates a signal to identify a specific point in the travel of piston 1. The CID signal is used for DIS logic and EEC-IV SEFI fuel delivery logic.

CIRCUIT - A system through which electricity flows before it returns to its source, thus having completed a circuit.

CLOSED LOOP - An operating mode of the ECA in which a control circuit samples output to determine how much of a change actually took place. Then, as required, the ECA makes another change to produce the desired result.

COIL - A number of turns of wire in spiral form, or helix, used to increase or strengthen the magnetic field around a conductor.

COIL PACK - An assembly of more than one coil into a single module, as in DIS ignition coil packs.

COMPUTER TIMING - The total spark advance in degrees before top dead center, calculated by the EEC-IV module, and based on input from a number of sensors.

CONDUCTOR - A material, normally metallic, that permits easy passage of heat or electricity.

CONTINUITY - A condition where a circuit is closed or continuous between given points.

CONTINUOUS CODES - Service codes stored in keep alive memory (KAM) as a result of a failure (open or short), either intermittent or constant, detected in one of the sensor circuits. These codes are issued as a result of information stored during continuous Self-Test, while the vehicle was in normal operation.

CONTROLLER - Any device which is used to regulate or direct the operation of a system.

CRANKSHAFT POSITION (CP) SENSOR - A device which relays the actual position of the crankshaft to the electronic engine control system. Also known as the Profile Ignition Pickup (PIP) sensor.

CURRENT - A flow of electric charge; measured in amperes. By convention, current flow is from positive to negative.

DC (Direct Current) - An electric current that flows in only one direction and stays essentially constant in value.

DIGITAL - A signal that has two states; ON or OFF.

GLOSSARY

DIS (Distributorless Ignition System) - Ignition system design in which the secondary voltage is passed directly from an ignition coil to a pair of spark plugs, without the use of a distributor cap and rotor.

DIS IGNITION COIL - A coil pack in which each coil acts as a transformer to step up (increase) battery voltage to many thousands of volts. Each coil supplies high voltage for two spark plugs.

DIS MODULE - Ignition module used with the distributorless ignition system. The module provides ignition system ground, selects which coil to fire, controls current flow in coil primary circuits, generates diagnostic information, and provides failure mode effects management strategy.

DP (Dual Plug) - Ignition system which uses two spark plugs per cylinder, as on 2.3L DP engines.

DPI (Dual Plug Inhibit) - Feature of the dual plug engines which allow the ignition system to switch from single plug operation to dual plug operation.

DUAL HALL SENSOR - A crankshaft mounted dual Hall effect sensor that contains both the CID sensor and PIP sensor.

DUTY CYCLE - Measured during one full cycle of a signal, duty cycle is the ratio of the signals ON time to the sum of the ON time plus the OFF time. Expressed as a percentage.

$$\text{Equation: duty cycle} = \frac{\text{time ON}}{(\text{time ON} + \text{time OFF})} \times 100\ (\%)$$

DVOM (Digital Volt/Ohmmeter) - A meter which measures voltage and resistance and displays it in digital form on a liquid crystal display (LCD).

DWELL - The length of time that current flows through the primary circuit of an ignition coil for each spark generation.

ECA (Electronic Control Assembly) - An "on-board" microcomputer used in some electronically controlled engine systems.

ECT (Engine Coolant Temperature) Sensor - A device which provides engine coolant temperature information to an electronic engine control system processor.

EEC (Electronic Engine Control) - A computer controlled system of engine control.

EEC-IV MODULE - The "on-board" computer that receives data from a number of sensors and other electronic components. Based on data received and strategies programmed into the module's memory, the module generates output signals to control various engine functions.

EGR (Exhaust Gas Recirculation) - System designed to allow the flow of inert exhaust gases into the combustion chamber to cool the combustion and thus reduce nitrous oxides in the exhaust.

ELECTROMAGNETISM - Magnetism produced by an electric current. A soft iron core surrounded by a coil of wire temporarily becomes an electromagnet when an electric current flows through the wire.

ELECTROMECHANICAL - Refers to a device which incorporates both electronic and mechanical principles together in its operation.

ELECTRON - A negatively charged particle that forms part of an atom. Electrons in motion produce electric current.

EMF (Electromotive Force) - The force, or electric pressure, that causes current to flow in a circuit. Often referred to as voltage and measured in volts.

ENGINE RUNNING TEST - A section of the EEC-IV Self-Test that tests the inputs and control functions under controlled operating conditions. The actuators are exercised and checked for corresponding results.

FIELD COIL - A coil of insulated wire usually wound around an iron core. Current flowing in the coil produces a magnetic field. Also called "field winding."

FLUX - Electric or magnetic lines of force in motion to create a magnetic field. The location and strength of the lines of force determine the shape and size of the magnetic field.

FMEM (Failure Mode Effects Management) - Operating mode which attempts to keep the vehicle driveable in spite of certain EEC-IV or DIS system failures.

GLOSSARY

GND (Ground) - The negatively charged side of a circuit. A ground can be a wire, the negative side of the battery or even the vehicle chassis. The ground circuit must be at least the same size or bigger than the positive (hot) wire.

HALL EFFECT - A process where current is passed through a small slice of semiconductor material at the same time as a magnetic field in order to produce a small voltage in the semiconductor.

HO - Abbreviation for High Output.

HZ (Hertz) - A unit of frequency equal to one cycle per second.

IC (Integrated Circuit) - A small semiconductor device which contains circuitry that can perform numerous functions.

IDM (Ignition Diagnostic Monitor) - A digital signal that tells EEC-IV an ignition coil has fired. IDM provides diagnostic information about the ignition system and is used to drive the vehicle tachometer.

IGND (Ignition Ground) - A low current reference for the EEC-IV and DIS modules.

IMPEDANCE - The total opposition offered by an electric circuit to the flow of an alternating current. Impedance is the combination of resistance and reactance and is measured in ohms.

INDUCTION - The spontaneous creation of an electric current in a conductor as the conductor passes through a magnetic field or a magnetic field passes across a conductor. Measured in henrys.

INDUCTIVE REACTANCE - An opposing electromotive force (EMF) induced in a coil as a magnetic field around the coil starts to expand. This EMF impedes current flow in the coil.

INDUCTIVE RELUCTANCE - Resistance to the flow of magnetic lines of force (flux) caused by the design and construction of a coil.

INDUCTOR - A current carrying coil of wire, generally wound around a soft iron core.

INJECTOR - An EFI system electric solenoid. The solenoid, when energized, allows fuel flow into the intake track where it is mixed with air for combustion.

INPUT - Information provided to a microcomputer to allow accurate control of a system.

INSULATOR - A nonconducting substance or body, such as porcelain, glass, or bakelite, used for insulating wires in electric circuits to prevent the leakage of electricity.

KS (Knock Sensor) - A device designed to vibrate at approximately the same frequency as the engine knock frequency. The knock sensor provides information on engine knock to an electronic engine control system processor.

LEFT-HAND RULE - Used to determine the direction of the magnetic field around a conductor carrying current. Imagine your left hand around a conductor and your left thumb pointing in the direction of electron flow (negative to positive). Your fingers will circle the conductor in the same direction as the magnetic lines of force.

MASS AIRFLOW (MAF) SENSOR - A device used to measure the mass of the air being drawn into the engine by volumetric displacement. Sensor output is used to calculate injector pulse width.

MAGNET - Any metal that has the property of attracting iron or steel. This property may be naturally present or artificially induced. See ELECTROMAGNETISM.

MAGNETIC FIELD - Magnetic lines of force which can be detected at every point in a region. A magnetic field may be natural as with a permanent magnet or created when electricity flows in a wire conductor.

MAGNETIC LINES OF FORCE - The attracting or repelling forces created by magnets or electric currents. Also referred to as flux or magnetic flux.

MAGNETISM - The properties associated with the field of force produced by a magnet or an electric current.

MAP (Manifold Absolute Pressure) SENSOR - A sensor or its signal circuit that sends a varying frequency signal to the processor for calculation of barometric pressure based on manifold vacuum and manifold pressure.

MBT - Abbreviation for maximum spark for best torque.

MMF (Magnetomotive Force) - Magnetic force or pressure which causes the flow of magnetic flux.

GLOSSARY

OHM - A unit of electrical resistance measuring the opposition to current flow.

OHM'S LAW - A law of electricity which states the relationship between voltage, current and resistance. It takes an electromotive force of one volt to force one ampere of current through one ohm of resistance.

Equation: volts = amperes x ohms ($E = IR$)

OHMMETER - An instrument that measures resistance to current flow. Readings are in ohms.

OPEN CIRCUIT - A circuit which does not provide a complete path for the flow or current (no continuity).

OPEN LOOP - An electronic control system in which sensors provide information, the ECA gives orders, and the output devices obey the orders without feedback to the ECA.

OUTPUT - Decisions or commands issued by a processor to output devices to allow displays, actuators or other output devices to function.

OUTPUT DRIVER - A transistor in the output area of a control device that is used to turn various output devices ON and OFF.

OHC (Overhead Cam) - Engine design in which the camshaft is mounted on the cylinder head.

PERMEABLE - A characteristic of how good a material is as a magnetic path.

PIP (Profile Ignition Pickup) - A Hall effect vane switch which provides crankshaft position information to electronic controllers.

POLARITY - The difference in properties or powers between two bodies or the ends of one body, as in a magnet. According to the Current Theory, polarities in an electric circuit are established by an excess of electrons on one side (negative) and a deficiency on the other (positive).

POTENTIAL DIFFERENCE (Potential) - Electrical force measured in volts. Sometimes used interchangeably with voltage.

POWER - The amount of force or energy available to do work. Measured in watts.

Equation: Power = current x voltage ($P = IE$)

PRIMARY - A low voltage circuit or part of a circuit. The first stage, or input circuit, of a transformer.

PROCESSOR - The "on-board" computer module, such as the EEC-IV module, that directs engine control.

QUICK TEST - A functional diagnostic test of the EEC system consisting of Key On/Engine Off, Engine Running and "continuous" Self-Tests along with vehicle preparation and hookup. Results are displayed as a series of service codes.

RATIO - A fixed relationship between things in number, quantity or degree. Also, the relative size of two quantities expressed as a quotient of one divided by the other. The ratio of 8-to-1 is written 8:1 or 8/1.

REACTANCE - Opposition to the flow of current in a circuit caused by inductance or capacitance.

RELUCTANCE - The resistance of a material to the flow of magnetic lines of force.

RESISTANCE - The opposition offered by a conductor to the flow of electrical current; measured in ohms. Resistance varies in different materials and with temperature.

RESISTOR - Device which opposes flow of electric current in a circuit.

RPM - Abbreviation for revolutions per minute.

SC - Abbreviation for supercharged.

SECONDARY - A high voltage circuit or part of a circuit. The second stage or output circuit of a transformer.

SEFI (Sequential Electronic Fuel Injection) - Port fuel injection, triggered off ignition timing, that fires each injector separately as the intake valve opens for that cylinder.

SENSOR - A device that measures an operating condition and provides an input signal to a processor.

SELF-TEST - A part of the functional "Quick Test" diagnostic procedure which verifies that sensors, actuators, and EEC-IV module are connected and operating properly.

GLOSSARY

SEMICONDUCTOR - General term for transistors, integrated circuits, and other electronic devices made of material, such as silicon, that are poor electrical conductors.

SERVICE CODES - A limited number of two-digit codes representing the results of Self-Test. The codes indicate a problem has occurred somewhere within the EEC system. Codes are communicated via the Self-Test Output Connector as a series of timed pulses read either on a STAR tester or VOM.

SHO - Abbreviation for super high output.

SHORT CIRCUIT - Defect in an electric circuit in which electricity flows directly from one conductor to another rather than through the intended circuit.

SIGNAL - A voltage condition that transmits specific information in an electronic system.

SOLID-STATE - Any electronic circuit that does not use vacuum tubes can be considered solid-state. The term solid-state refers to circuits that use transistors, integrated circuits, and/or other semiconductors.

SPARK PLUG - Electrical component that produces a spark to ignite the air/fuel mixture in the cylinders.

SPOUT (Spark Output) - The spark output signal from the EEC-IV module is used to control engine timing during different operating conditions.

STI (Self-Test Input) - The circuit in EEC systems which is used to initiate Self-Test.

STO (Self-Test Output) - The circuit in the processor which transmits the service code to either a STAR tester or VOM for display.

SQUARE WAVE - A digital on-off type of signal that has a very fast rise and fall time.

STAR TESTER (STAR) - An automatic readout device which displays Self-Test service code and continuous codes in digital format. This tester connects to the EEC-IV's Self-Test output connector.

TDC (Top Dead Center) - The extreme highest point of the piston during its stroke.

TFI (Thick Film Integrated) - Small ignition module which is generally mounted on the distributor and fires the ignition coil.

TP (Throttle Position) Sensor - A device which provides information on the throttle position to the electronic engine control system processor.

TIMING - Relationship between spark plug firing and piston position. Usually expressed in crankshaft degrees before or after top dead center (TDC) of compression stroke.

TRANSFORMER - A device consisting of two coils of insulated wire; a primary coil and a secondary coil. Power is transferred from the primary to the secondary through induction. The total amount of power present ideally remains the same from primary to secondary, but the ratio of voltage to current may vary.

TRANSISTOR - A small solid-state electronic switching device which uses semiconductors. Widely used to replace vacuum tubes and switches.

TRANSITION - The process of changing from one state to another, such as a digital signal changing from low to high.

VBAT - Abbreviation for vehicle battery voltage.

VOLT - A unit of measurement for the force or pressure which causes current flow in a circuit.

VOLTAGE - The electrical force or pressure which causes current flow in a circuit. Measured in volts. Also known as electromotive force (EMF).

VOLTMETER - An instrument that measures voltage in units called volts.

VREF (Reference Voltage) - Power supplied by the processor to some sensors regulated at a specific voltage. For example, EEC-IV sensors are regulated to 4-6 volts.

WATT - A measurement of power. One volt multiplied by 1 amp equals 1 watt, and 746 watts equal 1 horsepower. One "kilowatt" equals 1000 watts.

Equation: Power = Voltage x current ($P = EI$)

WIRING HARNESS - A bundle of insulated electrical wires covered by an additional insulating jacket. The individual wires emerge from the harness at different points to go to various components.

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